AMERICAN MACHINIST

A JOURNAL FOR MACHINISTS, ENGINEERS, FOUNDERS, BOILER MAKERS, PATTERN MAKERS AND BLACKSMITHS.

VOL. 17, NO. 15. WEEKLY. | NEW YORK, THURSDAY, APRIL 12, 1894. | $3.00 per Annum. SINGLE COPIES 6 CENTS.

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The Robertson-Thompson Indicator.

With this we give illustrations of a new Robertson-Thompson indicator showing its design so plainly as to make a lengthy description of its general construction unnecessary. It is a standard size instrument with piston ½ inch area.

One of its important features lies in the simplicity and accuracy of its parallel motion constructed to make any deviation of the pencil from a straight line in its limited motion practically impossible. The accurate motion of the pencil arm is secured by the small controlling lever attached to it, and by having the lower pivots of the fulcrum link, the piston-rod link, and the pencil point in a straight line for all positions of the pencil arm. The fact that this line and a line drawn through the upper pivots of the same links, and the pencil point, in connection with the center line of the fulcrum link form a triangle for all positions of the pencil, insures parallelism between the fulcrum, and piston-rod links, which is claimed to add greatly to the accurate motion of the pencil. The pivots are free from any appreciable lost motion, and with ordinary usage will remain so for an indefinite length of time.

The piston rod is made of steel, hollow, and threaded on the inside to receive swivel rod which permits of the adjustment of the pencil to any height on the drum.

The drum is 1¾ inches diameter, is as light as is consistent with ordinary use, is turned on centers, and provided with a bearing 1½ inches long at the bottom, and ½ inch long at the top, and is further provided with cone bearings at the top and bottom of lower bearing to take up end play on the spindle. The spring in the drum can be adjusted for any speed, high or low, by quarter revolutions.

The guide pulley admits of the chord being led in every direction without the use of carrying pulleys.

The instrument can be readily changed from right to left, and is well adapted, on account of its light moving parts, to any high speed engine. It is made almost entirely of brass, heavily nickeled; but for ammonia purposes, it is made of steel. The workmanship, as well as the material, is of a quality as to make the instrument an exceedingly reliable one.

Reliable reducing wheels and planimeters also interest engineers. Fig. 2 shows a reducing wheel made of aluminum. It is not intended for attachment to the indicator, but as a permanent fixture. Fig. 3 shows a standard averaging planimeter, which gives the mean effective pressure without computation.

The indicators, reducing wheel and planimeter are manufactured by Hine & Robertson Co., 68 Cortlandt street, New York City.

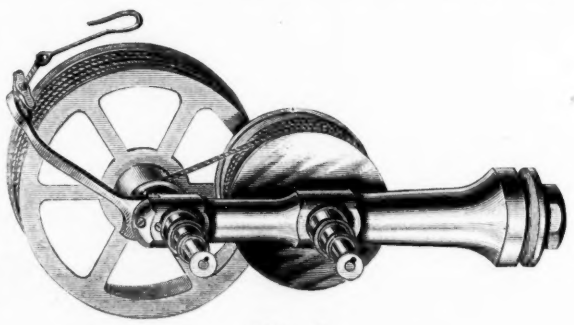


Fig. 2.

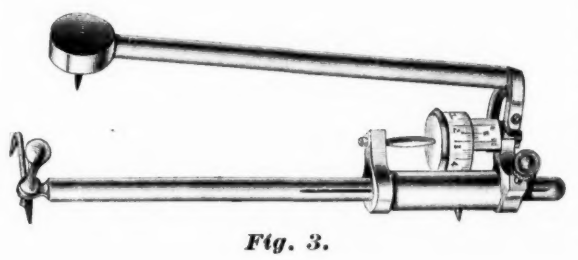
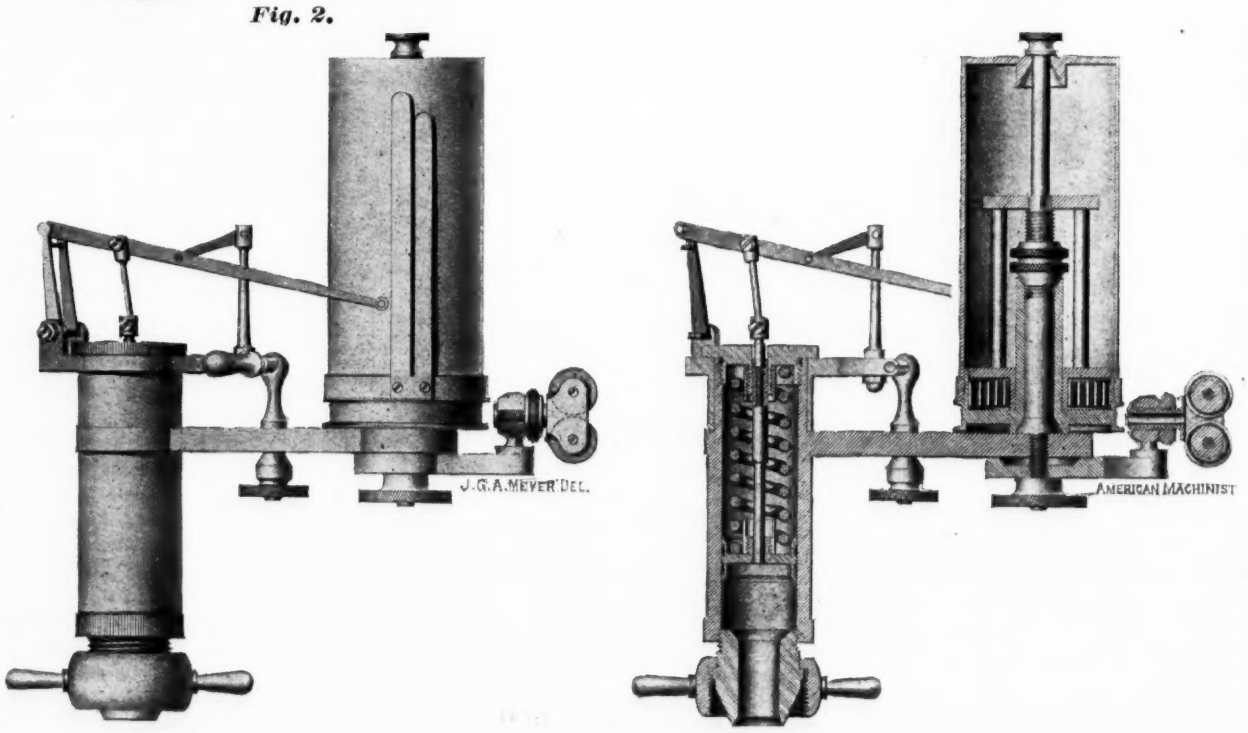


Fig. 3.



THE ROBERTSON-THOMPSON INDICATOR.

Power Required to Drive Machine Tools.

BY PROF. J. J. FLATHER.

In your issue of February 22d, I note in the Questions and Answers column a query from C. P., Brooklyn, who asks: "What horse-power will be required to drive twelve 14-inch lathes and four Brown & Sharpe universal milling machines?"

In an article by the writer, published in the AMERICAN MACHINIST of April 23, 1891, entitled "Horse-power Required to Run Lathes," it was shown that under ordinary circumstances when the lathe is in good condition, the brasses a good running fit and the belt not too tight, the required horse-power will depend: First, upon the speed at which the lathe is to be run; and second, upon the amount of work done by the tool.

From the results of experiments there given, it is found that the power required to drive the machine running light may be expressed by the equation:

$$H P_0 = 0\ 095 + 0.0012\ N$$

when the lathe is running without back gears; and

$$H P_0 = 0.10 + 0.006\ N$$

when the lathe is running with the back gears thrown in. In the above N equals the number of revolutions per minute, and the equations represent an average for lathes under 20 inches swing.

The amount of power required to remove metal is of course variable, depending upon the shape and condition of tool, the hardness of material to be cut, the rate of feed and depth of chip, and, to a slight extent, the diameter of work.

The size of lathe has, however, no appreciable effect upon the cutting power. Under ordinary conditions in regard to hardness of material and assuming the lathe tools to be those of the average machinist, the following expression will represent the work done in removing metal:

$$H P_1 = C\ W,$$

in which C is a constant depending upon the material, and W equals the weight of chips removed per hour, or that would be removed in one hour provided all conditions remained the same.

The average values of the constant were found to be:

For cast iron, $C = 0.026$,
For wrought-iron, $C = 0\ 030$,
For steel, $C = 0.044$.

From these equations we may obtain very closely the horse-power required to drive the 14 inch lathes.

Assuming the maximum speed to be about 300 revolutions per minute, the power required to run the machine light would be:

$$H P_0 = 0.095 + 0.0012 \times 300 = 0.45$$

The reduction in speed when the back gears are thrown in (with the belt on the same step) will be in the ratio of about one to nine, that is, the maximum speed when running with back gears will be about $\frac{300}{9} = 33$ R. P. M., hence the corresponding horse-power:

$$H P_0 = 0.10 + 0.006\ N = 0.30.$$

The greatest amount of work that could be turned out on this lathe would be about 14 pounds of chips per hour (wrought-iron) corresponding to a cutting speed of 20 feet per minute, a depth of cut equal to 0.125 inch, and a feed equal to 0.03 inch. The horse-power required to do this work would then be $H P_1 = C\ W = 0.03 \times 14 = 0.42$.

Now, to obtain the maximum total power required to run this lathe, we must find the horse-power required to drive the machine itself at various speeds corresponding to different diameters of work and take the greatest sum of $H P_0$ and $H P_1$.

Assuming diameters of from one to four inches, we obtain the results shown in the table below.

From which it is seen that the greatest power required to operate this lathe will not exceed about three-fourths horse-power—even under severe service—for it must be admitted that a cut which will remove ¼ inch wrought-iron with a feed of $\frac{1}{32}$ inch, at a speed of 20 feet per minute, is about as much as a 14 inch lathe is expected to do. If all the twelve lathes are working on similar cuts at the same time the horse-power required to drive will be 9, but as the character of lathe work is more or less intermittent, and as the depth of cut and feed are usually very much less than those considered above, it is safe to assume that one-half horse-power will drive one lathe at its maximum output, thus giving us 6 horse-power for the lot.

The power required to drive the milling machines is determined with less accuracy owing to the lack of reliable experiments on these tools. Hartig's experiments on milling machines were confined in most part to tests of surfacing machines with large radial mills carrying inserted cutters. His results on a gear cutter (capacity of machine 20-inch gear) showed that

Diameter of work in inches.	Revolutions per minute.	Horse-power required to drive lathe empty.	Horse-power required to remove metal.	Total H. P. required to operate lathe.
¼	76	0.19	0.42	0.61
1⅛	51 [geared	0.16	.42	.58
2	38 Back	0 33	.42	.75
3	26 "	0 26	.42	.68
4	19 "	0 21	.42	.63

0.11 horse-power was required to drive the machine empty, and that an additional amount equal to $C\ W$ is necessary to remove metal in which $C = 0.12$ for cast iron, and W = weight of chips removed per hour. The greatest amount of work done on this machine was 1.36 pounds of cast-iron cut out of the solid in a wheel of 52 teeth whose outside diameter was 10.30 inches, breadth of face = 1.53 inches, depth of tooth = 0.42 inch—practically 5 pitch. Three gears were cut at the same time.

From this we see that the work done, $H\ P_1 = C\ W = 0.12 \times 1.36 = 0.17$ horse-power, hence the total power required to operate was $0.11 + 0.17 = 0.28$ H. P.

Experiments made by Mr. Adam Herzog, at Purdue University, under the direction of the writer, showed that the horse-power required to run a small universal milling machine (Brown & Sharpe No. 1 without overhanging arm) varied both with the speed of cutter and with the rate of feed; in fact, with the highest rate of feed the power required was twice as great as when the machine was belted for the slow feed—the revolutions of spindle being the same in each case.

The maximum power required to drive the milling machine itself was 0.13 H. P. corresponding to the highest speed of rotation and the highest rate of feed. The maximum power required to remove metal was 0.28 H. P. In this case the material cut was cast iron 1.10 inches wide; the depth of cut = 0.15 inch, the feed 0.01 inch, and the cutting speed = 32 feet per minute; under these conditions the rate of work was 1 95 pounds iron chips milled per hour.

The total power required to operate the machine at this speed and rate of work was less than 0.3 H. P., and it is probable that even with a broader cut the total maximum power would not exceed 0.4 H. P.

As the equation for determining the power required to drive the machine light involves both the speed of cutter and the rate of feed, it will be sufficient here to state that with the mean feed the power varies from 0.01 H. P. with 70 revolutions of spindle, to 0.09 H. P. with 280 revolutions.

The power required to remove metal is obtained from,

$H\ P_0 = C\ W$ in which,
$C = 0.14$ for cast-iron;
$= 0.30$ for tool steel;
$= 0.10$ for bronze.

The average value of W as used in the above tests was,

0.8 for cast-iron,
0.6 for steel, and
0.9 for bronze.

From these considerations it may be assumed that three-tenths horse-power will be sufficient to run a small universal milling machine under ordinary conditions.

The total power required would then be, $12 \times 0\,5 = 6$ H. P. for twelve 14-inch lathes; $4 \times 0.3 = 1.2$ H. P. for four universal milling machines; to this we should add about 35 per cent. or 2 5 H. P. for friction in shafting, making a total of 9.7, or about 10 H. P.

Now that the electric motor has come to stay as a part of the equipment of the machine shop—that is of some machine shops—and its advantages as a source of power for isolated machines are causing its application to be more extended, a knowledge of the power required to drive each tool will be of value in determining the size and location of motors to be used in any given case.

As a rule the capacity of motors now being installed to drive iron working machinery is largely in excess of the power required. This may be due to two causes: First, the observed power required to drive machine tools, as determined from indicator cards taken from the engine, is very much greater than the actual power required to drive the individual machines, on account of the relatively large amount of power absorbed by friction in engine and shafting, and, second, a worthy desire on the part of the man who sells the motor that his machine shall not be taken out on account of its inability to do the work required—it is for this reason that we find a 15 or 20 H. P. motor running a 1 H. P. planer.

The inclosed table which has been compiled from various sources, principally from Hartig's researches,* may be used as a guide in estimating the power required to run a given machine, but it must be understood that these values, although accurately determined by dynamometric measurements for the individual machines designated, are not necessarily representative, as the power required to drive a machine itself is dependent so largely on its particular design and construction. The character of the work to be done may also affect the power required to operate; thus a machine to be used exclusively for brass work may be speeded from 10 to 15 per cent. higher than if it were to be used for iron work of similar size, and the power required will be proportionately greater.

It is to be regretted that some of the data from which these values have been deduced is so meager, but it is thought that as a matter of comparison they may have some value, and are therefore given a representation in the table

It may be noted that where power is to be transmitted to the machines by means of shafting and countershafts, an additional amount varying from 30 to 50 per cent. of the total power absorbed by the machines will be necessary to overcome the friction of the shafting.

HORSE-POWER REQUIRED TO DRIVE MACHINERY.

Designating Numbers.	Name of Machine.	Observed Horse-power. Total Work.	Running Light.
1	Small screw-cutting lathe 13½" swing. Back geared..	0.41	0.18 Varies from 0.15 with, to 0.34 without back gears.
2	Small screw-cutting lathe 12" swing. Back geared..	0.330	0 12 From 0.12 to 0.15
3	Screw-cutting lathe 17½". Back geared..	0 867	0.207 From 0.16 to 0.466
4	Screw-cutting lathe 20" (Fitchburg). Back geared..	0.47	0.12 From 0.12 to 0.31
5	Screw-cutting lathe 26". Back geared..	0.462	0 05 From 0.03 to 0.33
6	Large facing and turning lathe 80" face plate, will swing 108". Treble geared..	0.53	0.187 From 0.12 to 0.66
7	Large facing lathe will swing 68". Treble geared..	0.91	0.37 From 0.39 to 0.81
8	Wheel lathe 60" swing		0.23 to 3.40
9	Small shaper (stroke 4", work can traverse 11")..	0.16	0.086 From 0.086 to 0.26
10	Small shaper, Richards (capacity 9½" stroke x22" traverse).	0 24	0.07 From 0.07 to 0 12
11	Shaper (15" stroke Gould & Eberhardt)	0 63	0.21 Varies from 0.001 to 0.47
12	Large shaper, Richards (capacity 29" stroke x 91" traverse)	1.14	0.26 From 0.15 to 0.73
13	Crank planer (capacity 23"x27"x28½" stroke)	0.24	0.12 From 0.12 to 0.40
14	Planer (capacity 36' x36"x11 feet)	0.84	0.27
15	Large planer (capacity 76"x76"x57 feet)	1.47	0.60
16	Small drill press	0.62	0.39
17	Upright slot drilling machine (will drill slot 2½" diameter)	0.41	0.15 From 0.15 to 0.43
18	Medium drill press	1.33	0.62
19	Large drill press	1.24	0.62
20	Radial drill 6 feet swing	0.53	0.44 Varies from 0.1 with, to 0.44 without back gears.
21	Radial drill 8½ feet swing	0.67	0.30 Varies from 0.12 with, to 0.80 without back gears.
22	Radial drill press	1.08	0 46
23	Slotter (8" stroke)	0.28	0.09 Varies from 0.05 to 0.25
24	Slotter (9½" stroke)	0.44	0.22 Varies from 0.15 to 0.65
25	Slotter (15" stroke)	0.95	6 57 Varies from 0.43 to 0.94
26	Universal milling machine (Brown & Sharpe No. 1) without overhanging arm	0.23	0.01 Varies from 0.003 to 0.13
27	Milling machine (13" cutter-head, 12 cutters)	0 66	0.26 Varies from 0 26 to 0.55
28	Small head traversing milling machine (cutter-head 11" diameter, 16 cutters)	0.18	0.10
29	Gear cutter will cut 20" diameter	0.28	0.11
30	Horizontal boring machine for iron, 22½" swing	0 93	0.12 Varies from 0.10 to 0.12 with back gears, from 0.10 to 0.25 without back gears.
31	Hydraulic shearing machine	1.52	0.37
32	Large plate shears—knives 28" long, 3" stroke	7.12	0.67
33	Large punch press, over-reach 28", 3" stroke, 1½" stock can be punched	4.41	1.00
34	Small punch and shear combined, knives 7½" long, 1½" stroke	0.79	0.16
35	Circular saw for hot iron (30½" diameter of saw)	4.12	0.61
36	Plate-bending rolls, diameter of rolls 13", length 9½ feet	2 70	.54
37	Wood planer 13½" (rotary knives, 2 horizontal and 2 vertical knives)	4.24	3.35
38	Wood planer 24" (rotary knives)	3 03	1.42
39	Wood planer 17½" (rotary knives)	4.63	1.25
40	Wood planer 28" (rotary knives)	5.00	0.74 for surface cutters. 0.17 with side cutters.
41	Wood planer 28" (Daniel's pattern)	3.20	1.45
42	Wood planer and matcher (capacity 14½"x4¾")	6.91	4.18
43	Circular saw for wood (23" diameter of saw)	3.23	0.70
44	Circular saw for wood (35" diameter of saw)	5.64	1.16
45	Band saw for wood (34" band wheel)	0.96	0.19
46	Wood mortising and boring machine	0.49	0 34
47	Horizontal wood-boring and mortising machine. Drill 4" diameter, mortise 8½ deep x11½" long	3 68	1.67 Varies from 0.65 to 2.0
48	Tenon and mortising machine	2.11	1 42
49	Tenon and mortising machine	2.73	0.61
50	Tenon and mortising machine	2 25	2.17
51	Edge molder and shaper. (Vertical spindle)	2.00	1.30
52	Wood-molding machine (capacity 7½x2½). Horizontal spindle	2.45	2.00
53	Grindstone for tools 31" diameter, 6" face. Velocity 680 feet per minute.	1.55	0.32
54	Grindstone for stock 42" diameter, 12" face. Velocity 1,680 feet per minute	3.11	0 24
55	Grindstone	1.08	.62
56	Emery wheel 11½" diameter x ¼". Saw grinder	0.56	0.40

* *Versuche uber Leistung und Arbeits-verbrauch der Werkzeugmas.hinen.*

Combining Indicator Diagrams From Compound Engines.

By Frank H. Ball.

In the study of engines where steam is expanded through two or more successive cylinders, the diagrams are often combined, as in Fig. 1, page 3, for the purpose of comparing the aggregate result with the expansion of the same volume of steam in a single cylinder. Such combinations are made by first reducing the relative lengths of the diagrams to that which shall correspond to the cylinder ratio and then placing them at such distances from a common clearance line as to correctly represent the clearance in each cylinder.

This is the method used in steam engine literature taught in our technical schools, and practiced by steam-engine experts, and yet it is very inaccurate and misleading, and at best only a crude approximation of the truth and ought to be abandoned for better methods.

With this rather startling announcement let us proceed to investigate the possible magnitude of the error which this ancient and approved method contains.

Fig. 1 represents a combined set of diagrams from the steamship "Holyrood," which appears on page 696 of the second volume of D. K. Clark's treatise on the steam engine, edition of 1890.

This diagram is selected because of the high authority of the work and not because of the magnitude of the error which in this case happens to be small.

$B\ C$ represents the theoretic expansion curve with which the successive expansion curves of the diagrams are compared, and the area of $A\ B\ C\ D\ E\ A$ is the basis of comparison with the aggregate areas of the several diagrams.

To simplify this investigation, let Fig. 2 represent a set of theoretic diagrams from a compound engine whose high-pressure cylinder has 20 per cent. clearance and the low 10 per cent., with a cylinder ratio of 2.

Fig. 3 represents these theoretic diagrams combined in the usual manner.

In Fig. 4 the same diagrams are combined by another method which will hereafter be called "the compression curve method."

By this method a complete compression curve is first constructed, as $K\ F$ in Fig. 4.

This curve may be arbitrarily located to represent any desired clearance, or the clearance may be assumed to be zero, in which case the line $E\ A$ would represent the compression curve.

In Fig. 4 the compression curve selected is a continuation of the compression curve of the low-pressure diagram, which is a convenient one to use.

Horizontal lines are then drawn through the diagram, as in Fig. 2, and the compression curve completed to M, as shown by dotted lines.

Measurements on the horizontal lines are reduced in length to correspond with the cylinder ratio in the usual manner, and are transferred to the compression curve of Fig. 4, thus constructing the high-pressure diagram here shown, whose compression curve coincides with the continuous compression curve $K\ F$ of the combined diagram.

It is, of course, understood that Figs. 3 and 4 represent equal areas of work in corresponding diagrams, and $B\ C$ represents the theoretic expansion curve in both cases.

These diagrams being theoretic diagrams, their expansion curves should coincide throughout with the continuous curve $B\ C$.

In Fig. 4 this is the case, and in Fig. 3 the error of the accepted method is apparent.

When comparing the total work realized with that due to the same volume of steam expanded in a single cylinder, we have for Fig. 3 as follows:

Ratio of work $= \dfrac{\text{Aggregate indicated work}}{\text{Work represented by area of } A\ B\ C\ D\ E\ A} = .74.$

By the same method we have from Fig. 4 as follows:

Ratio of work $= \dfrac{\text{Aggregate indicated work}}{\text{Work represented by area of } F\ B\ C\ D\ K\ F} = .97.$

From the same theoretic diagrams then we have the following conflicting results:

By the accepted method, 74 per cent.

By the compression curve method, 97 per cent.

The only losses in these theoretic diagrams are represented by the areas of the three small triangles of free expansion, whose combined areas equal 3 per cent. of the total area of $F\ B\ C\ D\ K\ F$, so that of this total area 97 per cent. is indicated work, and 3 per cent. free expansion.

Fig. 5 represents the diagrams of Fig. 1 combined by the compression curve method.

In the graphic comparison of the expansion curves the difference between the two methods is not so apparent as in Figs. 3 and 4, but is still noticeable.

Comparing the areas we have the following:

For Fig. 1. Ratio of work $= \dfrac{\text{Aggregate indicated work}}{\text{Work represented by area of } A\ B\ C\ D\ E\ A} = .69.$

In the same manner we have from Fig. 5 as follows:

Ratio of work $= \dfrac{\text{Aggregate indicated work}}{\text{Work represented by area of } F\ B\ C\ D\ K\ F} = .71.$

If this compression curve method is right, the old method is very wrong and misleading, and ought to be abandoned as too primitive for the requirements of to-day, and particularly so in view of the fact that the more exact method is no more difficult, and requires no more time or skill than the old method. It is true that by the old

method the points of cut-off and the respective expansion curves of each of the diagrams are so placed as to correctly represent the total volume of steam expanded in each cylinder, including the contents of the clearance spaces, which is not necessarily true of the compression curve method, but the combined diagram cannot furnish any information in this direction that is not better and more accurately obtained from the original diagrams before they are combined.

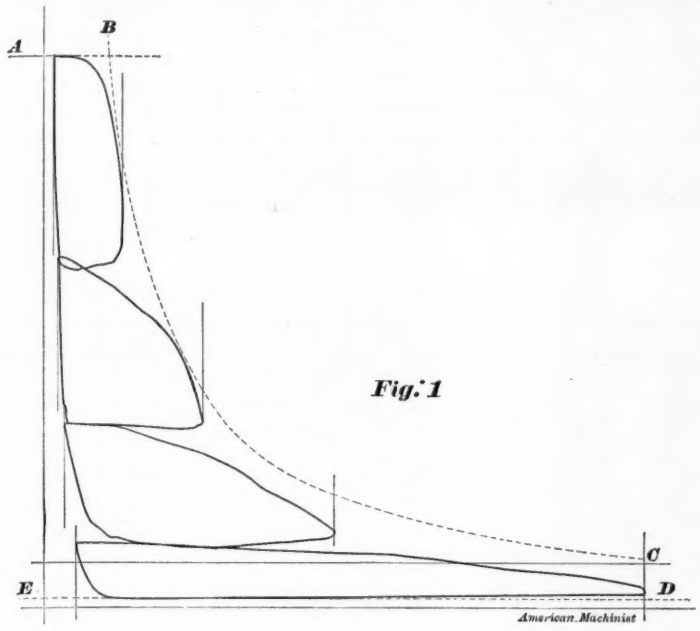


Fig. 1

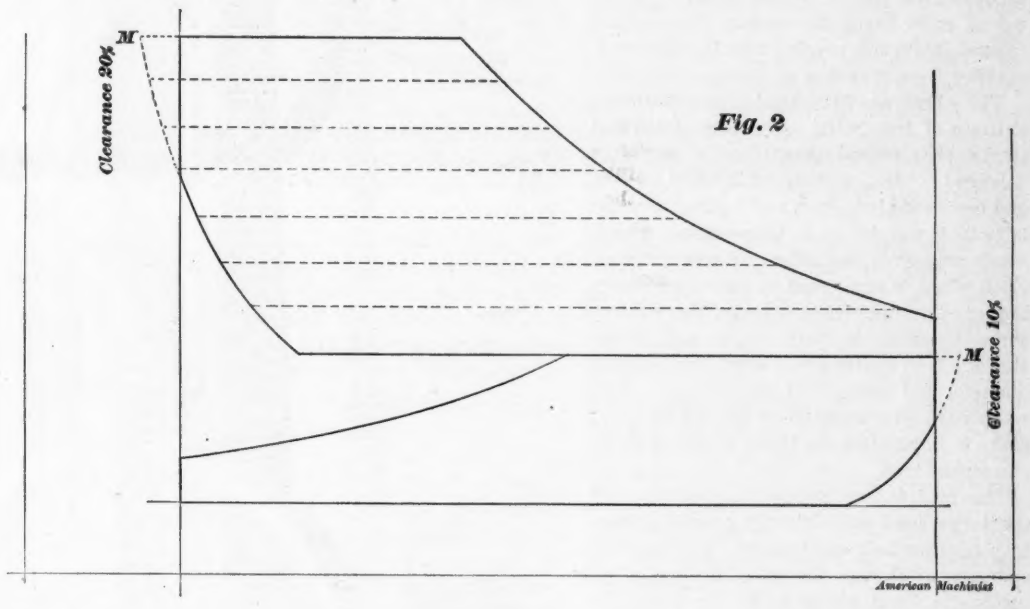


Fig. 2

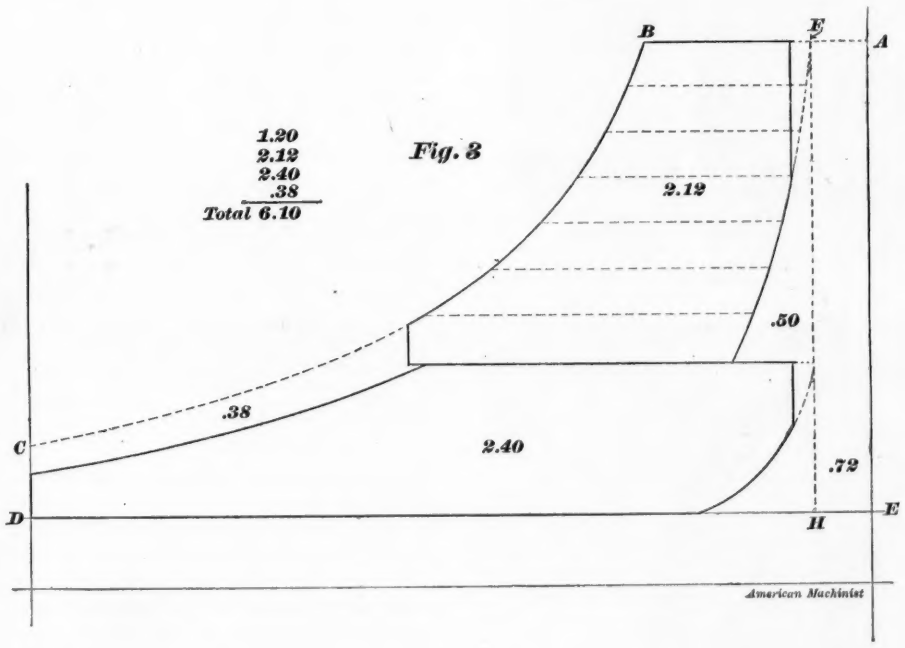


Fig. 3

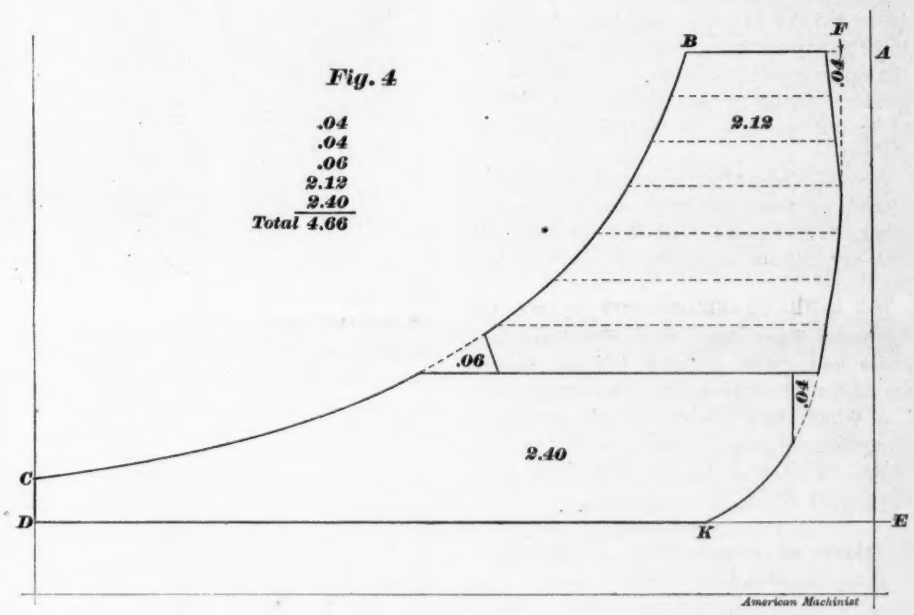


Fig. 4

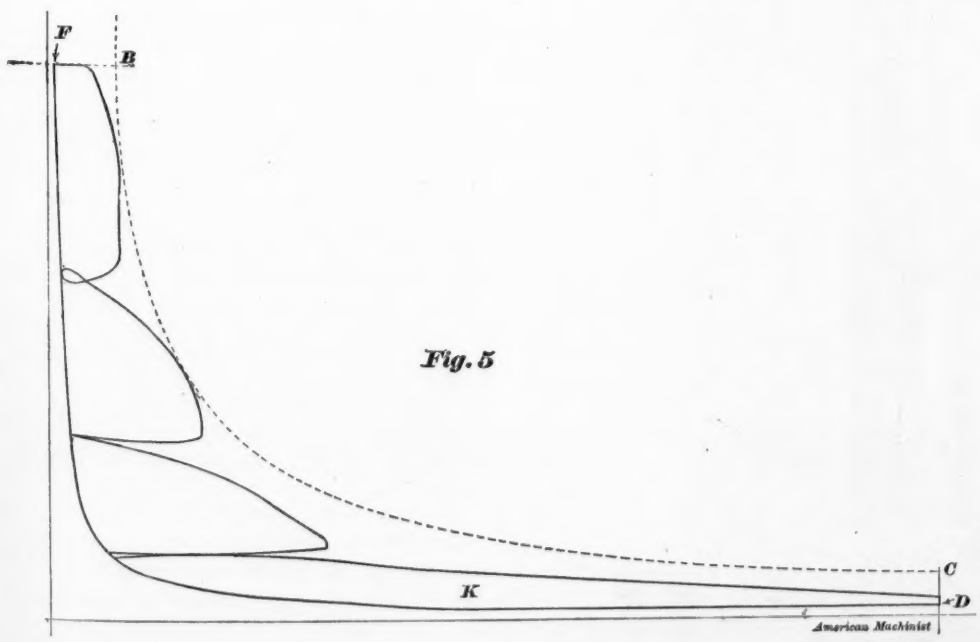


Fig. 5

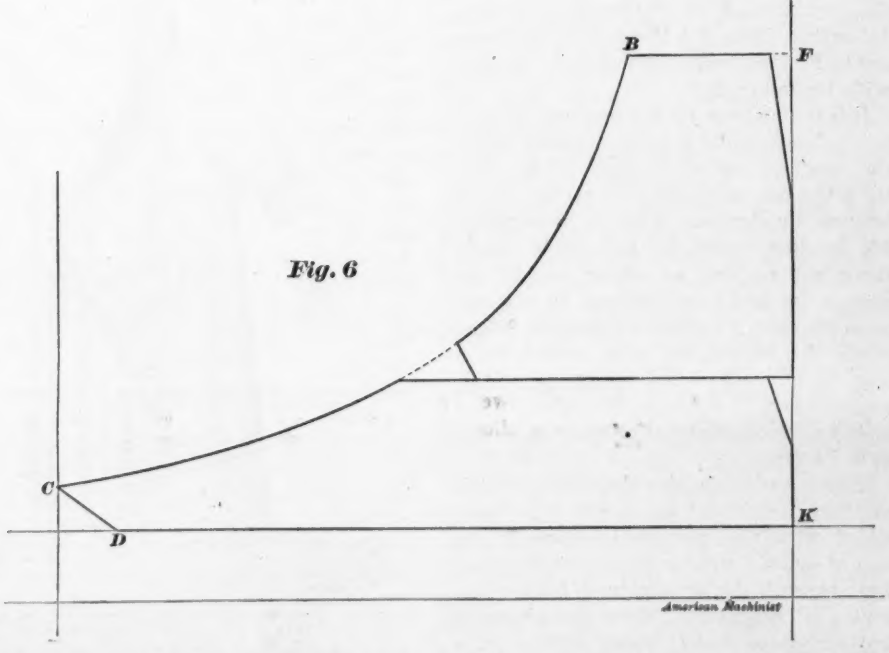


Fig. 6

If diagrams are to be combined it must be for the purpose of obtaining information that is not afforded by studying them singly, and this information is in the direction of a comparison of the aggregate performance of the system with a similar expansion completed in a single cylinder, first, by a graphic comparison of the successive expansion curves with a continuous curve, and second, by comparing the actual area of the aggregate diagrams with the area of a single theoretic diagram expanding the same initial volume of steam to the same terminal volume.

In this investigation the steam expanded in each cylinder is of no importance considered apart from that which is restored by compression.

In other words, the steam actually used is the only quantity to be considered, and that is measured by the distance between the compression curve and the expansion curve, therefore the compression curve becomes the base of measurement instead of the clearance line.

In combining diagrams by the compression curve method, any clearance which is most convenient may be assumed. It is often most convenient to use the same clearance that is found in the low-pressure cylinder, thus making it unnecessary to reconstruct this diagram, and its compression curve may be continued upward and used as the compression curve of the combined diagram.

If more convenient, however, the clearance may be assumed to be any other amount as already stated, or it may be assumed to be zero, which latter condition, however impossible in an engine, is none the less truthful in its graphic showing of the performance of the engine.

When the clearance is assumed to be zero the compression curve becomes a vertical straight line coinciding with the line representing the clearance space, and all the horizontal measurements of the diagrams are laid off from this vertical line.

Fig. 6 represents the diagrams of Fig. 2, combined with the clearance assumed to be zero.

Here $B\ C$ represents the theoretic expansion curve, as in Fig. 3, and following the comparison there made the same conclusions will be reached. Thus:

$$\text{Ratio of work} = \frac{\text{Aggregate indicated work}}{\text{Work represented by area of } F\ B\ C\ D\ K\ F} = 0.97.$$

If all the diagrams are to be reconstructed in combining them the zero clearance will be the most convenient one to assume.

Hardening Wrist Pins.

Sparks from the Crescent Anvil answers a correspondent as follows about hardening wrist pins: "We regard the hardening of such large pieces as very dangerous and never recommend it. If such a surface is absolutely required we would suggest case-hardening, and to this end would make the pin of dead soft stock, and when rough-turned inclose it in an air-tight box, filling it with animal charcoal, and then keep the whole at a good red heat for 24 hours. After cooling, slowly and carefully reheat to a nice red and then harden it; it would then be ground to the proper dimensions; but if the pin were for our own use we should vastly prefer to make it of much higher carbon steel, anneal it just a little, so as to enable it to be machined easily, and then use it without any hardening whatever; this would produce a strong, safe wrist, and one that would polish beautifully. For our own use we would not have or use *hardened* pins."

Band Re-sawing Machine.

We present herewith a front and a rear view of an improved band re-sawing machine, which has a capacity to saw stuff 36 inches wide, 12 inches thick.

It is, of course, intended for use in large mills where a machine of great capacity is required.

Though capable of doing very heavy work, the machine can also do light work, and an improved system of feed gearing—having the two front feed rolls close to the saw blade, and a tension device connecting the top of roller brackets—enables the machine to straighten the plank while being sawed, making a great saving of time and material.

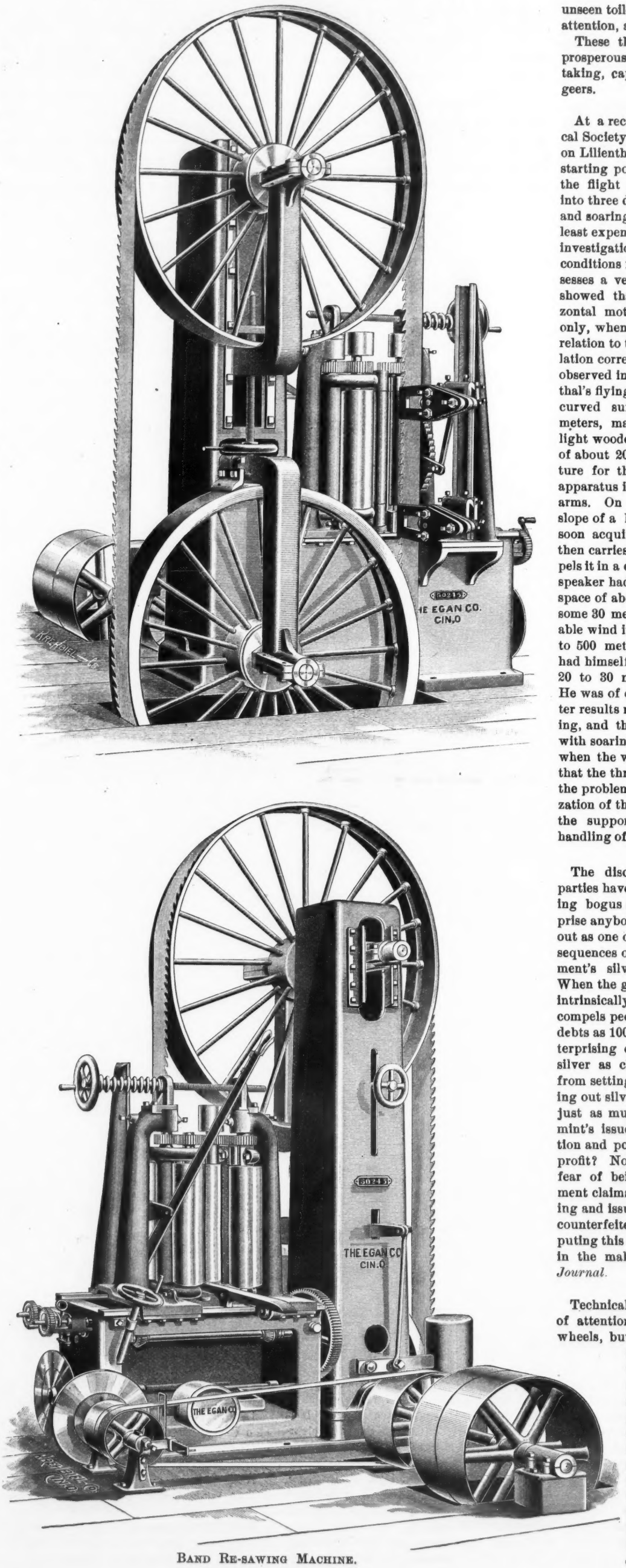
The wheels are 60 inches in diameter, made entirely of iron, with extra large hubs and steel spokes, placed staggering and perfectly balanced. The lower wheel is made thicker and more solid in the rim and is given thereby increased weight and momentum, which much improves the action of the machine. Each wheel is supported by an outside bearing on each side of the column, there being three bearings to both upper and lower shafts. The shafts are of steel, are large in diameter and run in self-oiling boxes. The wheels are so connected to the shafts as to make it impossible for them to get loose or run out of true.

The feed is very powerful, consisting of six large feed rolls heavily geared, driven by a friction disk mechanism, enabling the operator to change the speed instantly, by turning a hand-wheel while the board is being fed through the machine. A ratchet lever handy to the operator is connected to the upper guide, made so as to change the guide instantly to suit the width of board to be cut, and hold the saw blade steady in the cut.

Several pieces of narrow stuff can be cut, placed between the rolls one above the other. The rate of feed is from 0 to 100 feet per minute, according to the work being done.

For saw-mills, large planing-mills, box factories, picture-back stock, furniture factories and trunk makers, jobbing shops, etc., the machine is especially recommended.

A 6-inch saw blade, and all necessary wrenches, etc., are furnished with the machine, which is built by The Egan Co., Cincinnati, Ohio.



Band Re-sawing Machine.

Relation of Engineering to Progress and Civilization.

In the "School of Mines Quarterly" for January, Prof. F. R. Hutton has a thoughtful article upon "A Relation of Engineering to Progress and Civilization." It closes with the following:

It is unfortunate for the engineer that his work, fundamental to so much which makes the comfort and civilization of the day, should be concealed and disregarded simply because it underlies. Without the engineer, life in cities would be impossible where there was no gas, no water supply, no sewage, no food supply except by wagons, no motive power but human muscles. There would be a patrician class served by a class of slaves, and that great, powerful, conscientious, reliable middle class, which makes a nation great and prosperous, would be unknown.

Even in the Columbian Exposition, which has been considered the flower and example of what this century has done in the way of artistic culture and industrial progress, beneath the architectural beauty and genius of conception, there lies concealed and embedded many weary months of a burning of midnight oil, and of the expert skill of the engineering toiler in the preparation of the ground and the erection of the structures. Those who delighted in the luminous fountains by night and the marvelous effect of illuminations and the ghost-like flitting of the launches on the lagoons gave, probably, hardly a thought to the pulsing pumping engine, and to the whirring dynamo, over whose production the engineer had presided, and over whose regular march a faithful, conscientious, but unseen toiler, was watching with a ceaseless attention, and he also an engineer.

These things make a nation great and prosperous, a fertile land, a reverent, painstaking, capable body of professional engineers.

At a recent meeting of the Berlin Physical Society, Dr. A. du Bois Reymond spoke on Lilienthal's experiments on flying. As a starting point he had chosen the study of the flight of birds, which may be divided into three distinct kinds—flapping, steering, and soaring. Of these the one demanding least expenditure of energy is soaring, and investigation showed that under certain conditions flight is possible if the wind possesses a vertical component. Experiments showed that surfaces can acquire a horizontal motion by the action of the wind only, when their curvature bears a certain relation to their superficies, and that this relation corresponds exactly to that which is observed in the wings of birds. Dr. Lilienthal's flying machine consists of a correctly curved surface whose area is 14 square meters, made by stretching linen over a light wooden frame, and having a weight of about 20 kilos. In its center is an aperture for the experimenter's body, and the apparatus is held in position by the person's arms. On running rapidly down a gentle slope of a hill against the wind, the latter soon acquires a vertical component, which then carries the flying apparatus and propels it in a direction against the wind. The speaker had seen Dr. Lilienthal sail over a space of about 120 meters, at an altitude of some 30 meters, in a minute; with a favorable wind it was possible to cover some 200 to 500 meters, and Dr. du Bois Reymond had himself taken leaps through the air of 20 to 30 meters under similar conditions. He was of opinion that by practice far better results may be obtained as regards soaring, and that then, by combining steering with soaring, it will be possible to fly even when the wind is unfavorable. It appears that the three essentials for the solution of the problem of flight are: (1) Correct utilization of the wind; (2) the correct shape of the supporting surfaces; and (3) correct handling of the apparatus.

The discovery at Omaha that private parties have gone into the business of making bogus silver dollars ought not to surprise anybody. It was what was pointed out as one of the possible and probable consequences of the debasement of the government's silver dollar by act of Congress. When the government coins a dollar that is intrinsically worth less than 70 cents and compels people to receive it in payment of debts as 100 cents, what is to hinder any enterprising counterfeiter, who can buy new silver as cheaply as the government can, from setting up his private mint and turning out silver dollars that are really worth just as much as those of the government mint's issue and shoving them into circulation and pocketing the 30 or more per cent. profit? Nothing will hinder him but the fear of being caught at it. The government claims the exclusive privilege of coining and issuing bogus dollars. The Omaha counterfeiters choose to take the risk of disputing this claim of a government monopoly in the making of bogus dollars.—*Evening Journal.*

Technical journals have given a good deal of attention of late to the failure of fly-wheels, but it is rather evident not any too much. Such failures are entirely too common, and it looks a little as if the rules relating to their safety should be revised. As engine speed is increased there seems always the intention to get more surface speed of fly-wheels, and it looks as if the proper limit may have been passed. Another thing that tends in this direction is the greatly increased speed of line shafts. Everything seems to be working in the direction of over speeding fly-wheels.

The Victor Engine.

The engine we illustrate herewith is one built in two sizes, viz., 4 and 8 horse power, by M. E. Howard, Indianapolis, Ind. No especial claim is made for these engines except that they are made of ample strength, ample wearing surfaces, and with all conveniences for taking up wear. The crank-shaft is forged; the connecting rod is of steel, with gun-metal boxes and wedge adjustment. The engines are made in quantities, and on the interchangeable plan, and we are informed that a good many of them have found their way into use.

LETTERS FROM PRACTICAL MEN.

To Make Castings Sound.

Editor American Machinist:

All of your correspondents agreed that the difficulty came from the condition of the mold or core and not from the iron, but it is not possible to give a proper opinion unless you have seen the job and the conditions under which it was made and the quality of the iron, and the fuel that was used in melting the iron; also the nature of the sand—as most of the difficulties in casting would be got rid of if you could prevent the generation of gas inside of the mold when pouring.

The trouble may be in not having the core properly vented; or in having the vent too near the surface of the core, or in the cope being too hard, or too wet. But you say that you have tried all of these prescriptions and the holes do not entirely disappear, but you have seemingly found an improvement. Well, if you make a change in your iron I think that you will get over your trouble, you might also change your style in molding your pans; if you would make them with the open side up, it would make your castings more solid on the bottom where it is most required, and you could, with a good rigging, make them just as cheap, and do away with nine-tenths of the risks which you are having.

Sulphur is the greatest enemy in the production of sound castings; it unites with iron from all sources up to 53 per cent., it makes cast-iron very fusible, but when melted it is very sluggish, and is filled with blow-holes when "set." In order to get good, solid castings you should not have more than .03 per cent. of sulphur; in order to get rid of sulphur you must use fuel that is free from it, and use "lime" or "fluor spar" in fluxing of your cupola. The best fuel that I have used in this country is the Frick Conneesville coke. It is practically free from sulphur.

Edward B. Gilmour.

Perhaps Some Reader Can Give Information.

Editor American Machinist:

We have in the shop a pair of emery wheels, 2 inches thick and 16 inches diameter; the center is made of cast-iron 8 inches in diameter, and looks as if the emery was pressed in the hub for the purpose of saving emery, as when we use a solid wheel down to 8 inches we throw it away. This pair of wheels came here about four years ago. No agent, letter or circular has ever been here. I would like to find out who made them, as I would not like to put them in, and have them burst and kill some of the workmen. We run Norton and Detroit wheels about 1,200 per minute at the highest when the wind is on. If you or any of your readers could tell me where they came from, you would oblige Safety.

Regular Polygons.

Editor American Machinist:

The interesting communications in your recent numbers on the "Construction of a Heptagon," prompt me to give to your readers the benefit of three little tables which I have carried for years in my notebook, and frequently have found very convenient.

They give the relative proportions of the inscribed circle, the circumscribed circle and the length of a side of the regular polygons, and are so grouped that either of two dimensions can readily be found from them when either of the third dimensions is given.

From Table I. are found the circumscribed diameter and the side when the inscribed diameter is given.

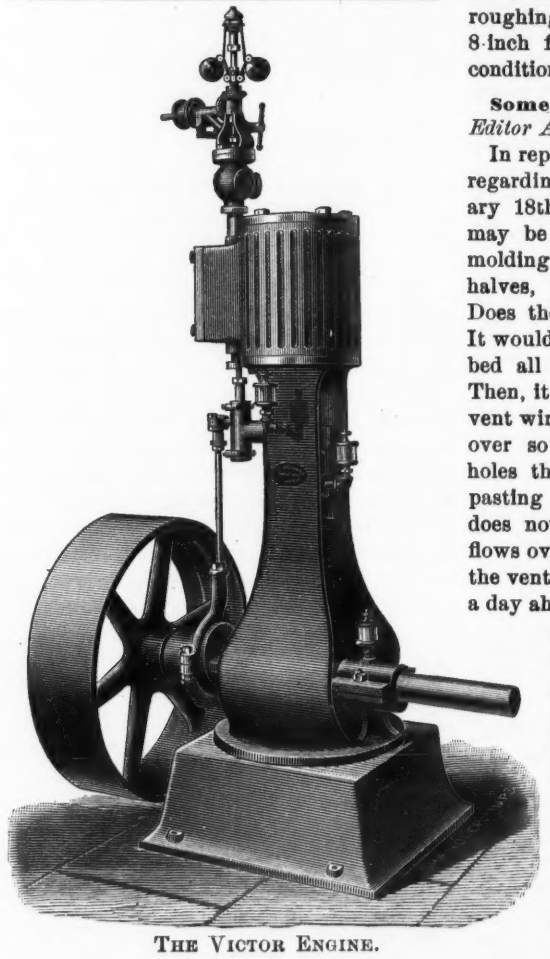
From Table II. are found the inscribed diameter and the sides when the circumscribed diameter is given.

From Table III. are found the inscribed diameter and the circumscribed diameter when the side is given.

POLYGONS.

Table I.

Number of Sides.	Inscribed Diameter.	Circumscribed Diameter.	Sides.
3	1.	2.0000	1.73206
4	1.	1.4142	1.00000
5	1.	1 2361	.7268
6	1.	1 1547	.5773
7	1.	1.1099	.4815
8	1.	1.0824	.4142
9	1.	1.0642	.3639
10	1.	1 0515	.3249



The Victor Engine.

Table II.

Number of Sides.	Circumscribed Diameter.	Inscribed Diameter.	Sides.
3	1.	.50000	.86603
4	1.	.70711	.70710
5	1.	.80903	.58779
6	1.	.86603	.50000
7	1.	.90101	.43389
8	1.	.92387	.38268
9	1.	.93967	.34200
10	1.	.95 02	.30900

Table III.

Number of Sides.	Side.	Inscribed Diameter.	Circumscribed Diameter.
3	1.	.5780	1.1557
4	1.	1.0000	1.4142
5	1.	1.3750	1.7015
6	1.	1 7330	2.0000
7	1.	2 0790	2 3047
8	1.	2.4150	2.6131
9	1.	2 7470	2.9240
10	1.	3.0770	3.2363

Example: A hexagon nut measures 2 inches from side to side, how much over the corners, and how long is each side?

Table I. gives the proportion of inscribed diameter to circumscribed diameter as 1 : 1.1547, then :

$2 \times 1.1547 = 2.3094$ length across corner.

The same table gives the proportion of inscribed diameter to side as 1 : .5773, then :

$2 \times .5773 = 1.1546$ length of side.

Example B: How large a round log must I have to cut from it a beam 12 inches square? Table III. gives the proportion of side to circumscribed diameter as 1 : 1.4142, then :

$12 \times 1.4142 = 16.968$ inches.

A. H. Raynal.

Milling Machine Feeds by the Foot.

Editor American Machinist:

I saw some very interesting articles on "Milling" which I read with pleasure. There were some remarkable feeds, and I doubted very much whether there was a milling machine made at the present day powerful enough to pull a cut of any width or depth 18 to 20 inches per minute. I am running one called the "slab milling machine," built after the style of the planer. After reading the article mentioned above, I thought it would be quite interesting to try some experiments in the way of feeds on the machine that I was running. My first attempt was eight inches a minute, and it did good work. By careful examination I found that the feed acted on the cutter and turned the cutter somewhat into a planing tool. My next attempt was 12 feet per minute; this was a little too fast, for it left the work somewhat in the shape of a heavy, woven, wire screen. The next experiment was a little more successful—I cut it down to five feet; this made a good roughing cut which was finished with the 8-inch feed and left the work in splendid condition for scraping. "Hustler."

Some Causes of Unsound Castings.

Editor American Machinist:

In reply to Mr. W. H. Drake, who wrote regarding holes in castings in issue of January 18th, my opinion is that the trouble may be in the core room, or, possibly, in molding. Now, these cores are made in halves, which are then pasted together. Does the core maker give it a good vent? It would be a good idea to have a cinder bed all around the core, top and bottom. Then, it would also be a good plan to take a vent wire and thoroughly vent the core all over so as to make it porous, leading the holes thus made into the main vent. In pasting the core together, I hope that he does not get so much paste on it that it flows over into the main vent and shuts off the vent in that way. Cores should be made a day ahead and kept in a warm and dry place. I do not like the idea of taking a hot core out of an oven and putting it in a mold. The first cores put in molds in the morning are damp all over at 3 o'clock, when the blast goes on.

Thomas Wathey says to flow 25 to 50 pounds of iron through the mold, but I should say that it would be better not to do this all at one time, but to flow the iron over the top of the core through the cope for, we will say, ten seconds; then put in the runner box five or ten pounds more. Then stop and do the same again, and this, I think, is the way to remedy a damp core. Another way is not to set the cores until the afternoon, and as near cast time as possible. It is possible that the fault may be with the core sand, which may be so close that it will not allow the gas to pass through to the main vent. A higher runner box would create a greater pressure, and one or two risers, say, $\frac{1}{2}''$ or $\frac{3}{4}''$ round, with a piece of soft clay on the top and weighted down tight so no air will go through, will make the air or gas break its way up through the cope. The cope, of course, should be vented thoroughly.

And still another cause of the difficulty may be that the molder got new sand and it may be too close, or, in other words, not porous enough to let the air through the cope. This might also come from too hard ramming over the core or from wet sand, as the sand that is wet in the morning is not evenly tempered all the way through. Sand should be wet at night. That blow-hole could come from a lump of wet sand. I suppose the molder takes his gas off through the cope, which, if through the nowel, a ten-second run-off would carry off any air that would settle between the iron and cope. I agree with Mr. E. B. Gilmour about using facing sand and blacking in the cope, but as H. C. Williams says, it is hard to tell until you see—it is like doctoring patients without seeing them. I think Alexander Cairns gives a good method of finding out whether it is in the iron or not. John Smith.

Human Nature as a Factor in the Machine Shop.

Editor American Machinist:

In these days of sharp competition, when the proprietor is on the lookout for the latest appliances for producing his specialty in the cheapest manner possible; when every item, no matter how small it may appear, is a factor in determining as to who shall lead in the race, it seems surprising that so few are taking advantage of the means which lie close at hand, and which are at the command of all.

Usually, when a man has come to the conclusion that his shop is being run at an expenditure which seems unwarranted, he starts in to reduce wages, cuts off supplies, etc., or else he will call in an expert, who will spend a few weeks prowling around the shop, and then come out with a brand new system, warranted to revolutionize the whole concern. Sometimes this has the desired effect; most generally, however, the result is not that which had been anticipated. For, after having ordered a reduction of 10 or 20 per cent., he is surprised that the expenditures have not decreased in like proportion. And if the new system is a success, some other fellow will come in and copy the best part of it, introduce it into his own business, and in a short time matters will settle back into their old routine, and then look out for a further reduction, or a shrewder expert, who will find further loop-holes through which the profits of the firm are escaping.

These seem to be the popular methods of reducing expenses; there are many others as varied almost as there are shops or proprietors, and, no doubt, they are in most instances absolutely necessary.

But, after all, are they really the most satisfactory means of accomplishing the end in view? Reduce wages, and you immediately create a dissatisfaction among the men, take away all ambition, and make them feel as though they ought to make up for the deficiency in their wages by a decreased amount of work, and, watch them as you may, there are all the chances in the world to shirk.

Introduce your expert, and somehow the natural inclination of most men will be to put obstacles in his way, and those who could help him most, will be least inclined to do so, fearing that in some way they will be injured by the new order of things.

There is a way, it seems to me, in which many things could be gained for the employer, and that, too, without creating any bad feeling. The difficulty, I think, is that many employers regard their men very much as they do the machinery in the shop; believing that all that is necessary is to start them up, or, in other words, to give the word, and off they go, blindly working away; so much work produced for each movement—a necessary evil. They never for one moment consider that their men are very much human in their natures, and that a certain kind of treatment will be as much appreciated as it would be by themselves.

What I am trying to get at is this: I believe that if human nature was made more of a study by the boss and his representatives in the shop, many points might be gained to their advantage. I might give many examples in which this could be proven, but one, I think, will suffice.

Very often it is desirable to introduce a cheaper grade of tool steel, for instance, which might for certain purposes answer as well as some of the more costly. The proprietor will send for a sample, have it forged into a lathe or planing tool, and send it into the machine shop. Usually, the foreman will give it to the machinist with these words: "The boss wants to have this tool tested; see how it will work." And then the machinist will start in to test it, and, oh! what a testing it will receive. He will then return it to the foreman, with the edge all battered up, making it appear as though the tool was incapable of standing any sort of treatment, and then return to his work with a smile of deep satisfaction, believing that he has done his full duty so far as that tool is concerned. If

the steel merchant depended upon this sort of testing in order to sell his steel, he would, without doubt, go into bankruptcy in short order. And yet, this is the way in which these matters are settled in many of our best shops.

If, on the other hand, the foreman is a student of human nature, and knows how to get the most out of his men, he will present the steel in an entirely different manner. Thus, for example: "Sam, I've got a piece of steel here in which I am very much interested; I think it will turn up those rollers as well as the —— steel you are now using, I wish you would work it in."

The man feels that he has an interest in that tool; to begin with, he knows that he will please the foreman if the steel can be used; whereas, in the other case, the disinterested manner in which the tool was given, did not show any desire to have the steel brought into use.

The machinist will (except in rare cases) in this instance give the tool a fair trial, not expecting nor trying to make it do the work which had never been done by the steel previously used.

I hope that I have brought out the idea I have in mind; I truly believe that if this method of dealing with men, trying to find out their weak points as well as the strong, and making the most of them, was studied with as much interest as some men put into many other things which are less worthy, there would be a better showing all around.

As some one has said, "Human nature is a queer commodity," and it well deserves deep thought and careful study. PRESTO.

Unsound Castings.

Editor American Machinist:

In reply to Mr. Ramp's inquiry regarding unsound castings, I would say, the castings should be made on end and poured from the bottom with four skim gates.

Two sprues are used for each gate; they are placed about six inches apart. A deep runner is cut in the cope from the pouring sprue to the skim sprue, and the gate to the casting is cut from the skim sprue in the drag. The work must be poured hard enough to keep the skim sprue full. If the skim sprue is not kept full, it would be better to leave it off altogether.

The inside surface of the chill might be cut with fine grooves lengthwise about a half inch apart—grooves to be fine enough so that the iron would not fill them, but allow them to carry off the air which might make the surface uneven. Red lead laid smoothly on the chill is also said to make smooth castings. A. K. BECKWITH.

Connections to Indicator.

Editor American Machinist:

Having read several communications in your columns concerning long and short connections for steam-engine indicators, it occurred to me that my experience along that line might prove interesting.

A short time ago I was requested to indicate an engine, and on going to the place found the reducing motion and connections all in place ready for the application of the instrument. The connections were made as follows: The cylinder was drilled and tapped as usual in such cases. Nipples about 6 inches long were screwed into the holes, with an elbow on the end of each. These two elbows were connected, and in the middle of the connecting pipe was an ordinary tee. On either side of this tee, and close to it were plug cocks. The stroke of this engine was 36 inches, and it was running nicely, although not perfectly. The indicator was attached and diagrams taken which showed the steam valves to be late in opening. The piston speed was nearly 700 feet per minute. The valves were adjusted so as to show vertical admission lines, but the engine did not pass the centers easily, and if it was stopped when it had just passed a center, and steam was admitted when it was in that position, it would start backward instead of forward. The engineer examined the marks by which the valves were set, and found that they had nearly one-half inch lead. They were put back where they were before. Was the indicator at fault, the marks wrong, or did the long connections cause diagrams to be taken that were misleading?

In another case I indicated an engine having a 36-inch stroke, and running at a piston speed of about 350 feet per minute. It was fitted with angle valves, which were one size larger than the side pipes, and a three-way cock was located midway between them. Several diagrams were taken which showed the valves to be properly set. The side pipe and the angle valve on one end were removed, and the indicator attached so that there was no obstruction whatever between the cylinder of the engine and the piston of the indicator, for the passage between the two was perfectly straight and short. This caused the instrument to be placed in a horizontal position. More diagrams were then taken, and no difference could be detected between them and those which were taken with the three way cock.

Not being fully satisfied with the result, I indicated still another engine under the following conditions: The stroke was 36 inches, as before, and the piston speed was about 425 feet per minute. The connections were made by first screwing in a short nipple followed by a globe valve at each end, into which was screwed a close nipple and an elbow. Centrally between these two elbows was an ordinary tee, into which was screwed a short nipple in a horizontal position, followed by an elbow looking upward to receive the indicator.

The reducing motion was also in position when I came, and diagrams taken with this outfit showed that the steam valves were late, and the cylinder pressure was at times as much as 30 pounds less than the boiler pressure. The expansion line was much higher than it should have been, showing that the steam valves leaked.

These side pipes were then removed, and the indicator attached to each end alternately, so that the steam passed through one globe valve and one elbow, the passage being quite short. Diagrams taken with this arrangement showed that the valves opened at the proper time, giving a vertical admission line, and a steam line at right angles to it, the junction of the two being remarkably square and full, and the expansion line showed that the steam valves were practically tight, although no change whatever had been made in the engine.

The foregoing experience, together with others along this line, has led me to conclude that if any one claims that long connections always show correct results, he is mistaken, and if another maintains that short connections are a necessity in all cases, he is in error.

If the piston speed is low, and the connections are of ample size, with few turns in them, then long connections will answer every purpose, at least in a majority of cases, but if the piston speed is high, it is much better to have the connections as short as possible.

In this case, as with many other things about steam engineering, it is not always absolutely necessary to follow one inflexible rule, but at the same time it may be well to call attention to the fact that, while long connections sometimes give correct results, short ones always do.

W. H. WAKEMAN.

Making Drill Jigs.

Editor American Machinist:

In issues of January 25th and February 22d, I notice articles on "Drill Jigs," by Barton Cruikshank and J. A. McGregor. They call to mind an old method, which I think a very good one, although not generally known among tool makers.

Fig. 1 represents a bushing plate with four holes, and their respective positions in relation to each other, marked 1, 2, 3 and 4.

In Fig. 2 *A A A A* represents a face-plate to a small lathe; there are no holes or slots shown for clamping the work, but be it understood, something of the sort is required.

B and *B'* show two parallel pieces screwed to face-plate exactly at right angles to each other, and in such position that when bushing plate is placed on *B'* it will be the right height to locate hole marked 1, from bottom of plate. Now slide bushing plate to the left 1¼ inches and locate parallel *B*. It is now plain, that to bore hole No. 1 it will be necessary to insert a piece 1¼ inches wide between *B* and bushing plate, shown in this operation in solid lines, Fig. 2.

To bore hole No. 2 insert a piece 1 inch wide between *B'* and bushing plate, which brings holes 1 and 2 exactly in line and 1 inch apart.

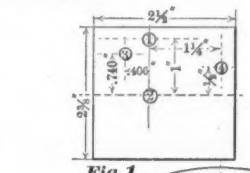


Fig. 1

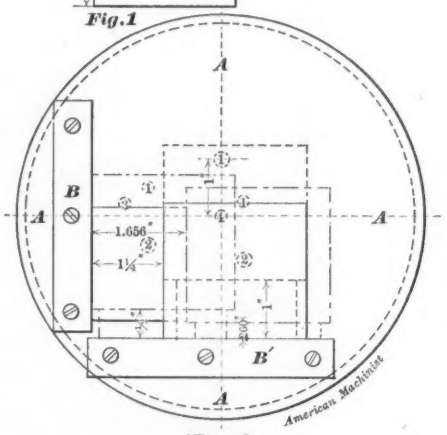


Fig. 2

For hole No. 3 insert a piece between *B* and bushing plate 1.656 inches wide, and between *B'* and bushing plate a piece .260 inch wide.

For hole No. 4 insert a piece ½ inch wide between *B'* and bushing plate, and bring bushing plate against *B*. Of course, the accuracy of this method depends in a great measure on the skill of the workman, as do all similar methods. I have seen a bushing plate made in this manner with ten holes in it, and the extreme variation was .0002 inch. J. G. KINGSBURY.

Drilling Steel.

Editor American Machinist:

I have a large number of holes to bore in crucible steel of about sixty points carbon, and thought some of your readers would be able to give me some information as to the best form or kind of drill, and method of boring to use; also the best lubricant to use. The holes are about 1⅝ inches diameter and about 8 inches deep in round blanks, and are bored in a heavy turret lathe; the holes must be true and concentric with outside of blanks and fairly smooth.

I have tried twist drills, but they have a bad trick of running out even when started very true in the first place; they also have a tendency to crack down through the center when a fairly stiff feed is used. I have also used the "hog nose" or half-round bit, they do not run out, and they cut a smooth, true hole, but I have had trouble with them squealing and binding also rucking (unless very hard) on back when used with a feed of about sixty per inch; which does not seem excessive for this size drill. I have used a mixture composed of whale oil soap, soda, lard oil and water boiled together, for a lubricant, and forced it on to lip of drill with considerable pressure by a small centrifugal pump; this works well as far as cutting is concerned, drill stays sharp and heat is kept down to a minimum, but the "hog nose" drill will squeal like a whole "car load of pigs" when just a trifle dull, and sometimes when sharp, it will act the same way, making it drive very hard. I thought the whole trouble was that the pressure of the cut forced the thin lubricant from under the pod of the drill and caused the squealing; so tried pure lard oil; this did not help matters any, and the drill heated up quickly. The trouble ceases when a fine feed is used, say, about 120 per inch, but the work comes out as slow as a "navy yard job," and yours truly gets that "tired feeling" you read about. Now, do I expect too much from a 1⅝-inch drill to bore in steel at a speed of 35 revolutions per minute, and a feed of from 40 to 60 per inch, when flooded with lubricant under pressure? The stock is well annealed and works free—no hard spots. Perhaps I do. If you can spare the space to publish this, it may be seen by some one of your many readers who has "been there" and knows the way, and would be willing to give others, as well as myself, the benefit of his experience, through the medium of your valuable columns. ENOTS.

American Watches in England.

Editor American Machinist:

In *English Mechanic and World of Science* some discussion has been published regarding the respective merits of Swiss, English, and American watches. In the issue of March 23d is found the following communication, signed J. H. S.:

"I was very much surprised to read in the *E. M.* that it was possible to buy an English watch which would hold its own against Swiss or Waltham when price was taken into account, and I should be only too pleased if your correspondent would enlighten my benighted vision as to *where* such watches can be obtained? I have been in a wholesale house for many years, where watches have been sold of recent years, and I should only like to know where I *could* buy English watches which for price, finish, and accurate performance would *be level* with the Waltham Co.'s productions. Of course, if very expensive watches are referred to, then the English watch perhaps can hold its own; but if we refer (and I think we do mostly) to watches of ordinary price, then the English are behind.

"If it were a fact that English watches could be produced to compare with Walthams, how is it that so many of the latter are sold in this country? Surely an Englishman would prefer an English lever to a Yankee if he could get either equally; but that question is only answered in one way, viz., the ordinary English lever of to day, with all the improved machinery, compared with a Waltham of similar price, *isn't in it*. I speak from experience, both as to the sale of them, and as to their performance. I have carried one 12 years, and its variation even now is not half a minute a month. Could you get an English lever of equal price to do it? I say not. Don't think I am an interested party to the sale of Walthams; I am not. I speak as I find, and I maintain that the English and the Swiss are not equal to the Yankees, price for price, and quality for quality." X. Y. Z.

Testing the Planimeter, Approximately.

Editor American Machinist:

Referring to your issue of March 22d, what is the matter with the planimeter that it should have fallen so low in the confidence which our friend "Quirk" has in its trustworthiness? Will you not kindly ask him to explain?

Possibly some few of your readers may not be familiar with the use of the planimeter, or acquainted with the limits within which its use may be considered accurate.

To them there may be some interest in a brief mention of a method of testing its accuracy quite obvious and very old-fashioned. Let them take a piece of drawing paper of even texture and thickness, as large as can be conveniently weighed upon a very delicate balance, say, 2″x5″, and from the weight of this piece the weight of the paper per square inch can be determined with great accuracy. Then let them draw, on a piece of the same paper, any figures whatever, rectangular or circular, of such form and dimension that they can be easily measured in linear inches, and can also be traversed by a planimeter point. After these figures have been measured by the planimeter and by linear measurement, let them be cut out carefully and weighed, and their areas thus determined, compared with the weight per square inch, are the standard piece first referred to.

In the same way real or assumed outlines of indicator diagrams can be drawn upon this standard paper, measured with the planimeter, cut out carefully, and weighed

as before. Thus a very clear impression can be obtained of the usefulness and trustworthiness of the planimeter within the clearly marked limits of its application.

Pittsburgh, Pa. P. BARNES.

Drawings vs. Sketches.

Editor American Machinist:

In issue of March 22d, Wm. Newton, speaking about working from sketches, remarks that had working drawings been made, "the machinist would have been able to read it intelligently." It recalled to mind an instance, when as draftsman, I was called upon to make a drawing of a device which required both pattern and machine work to complete. After receiving instructions from the chief draftsman, and getting a fairly good drawing well under way, was interrupted by the manager, who wanted that device in a hurry, no time to make nice drawings, a rough sketch good enough for now, the drawing could be made later for a record.

A rough sketch and considerable explaining told the head patternmaker what was wanted. The head patternmaker took lots of time to explain what was wanted to a high-priced workman, who, before finishing the pattern, was obliged to make inquiries at the drawing room. When the castings came from the foundry, the sketch had been lost, and then came another series of explanations, draftsman to superintendent, superintendent to foreman, foreman to machinist, until the job was finally completed and laid upon the bench. As a rule, the hurry is over with by this time. Several high-priced men spent time which might have been saved by a little time spent making an intelligent drawing which would last for ever. To-day there is nothing to show what was made except the patterns. Was anything saved but drawing paper?

W. R. G.

Paint for Ironwork.

The amount of paint for ironwork may be estimated by the following rule, given in the last annual report of City Engineer Horace Andrews, of Albany, N. Y., on the authority of Chief Engineer T. J. Swift, of the Delaware and Hudson Canal Company. This rule calls for five-eighths of a gallon of paint for each ton of iron for the first coat, and three-eighths of a gallon a ton for the second coat. The entire cost of repainting a 700-ton bridge in Albany was found to be $2.78 a ton, and the amount of paint purchased for the purpose in accordance with the above rule was found to leave a surplus of fifty gallons of the first coating and eight gallons of the second.—*The Engineering Record.*

If the men in charge of railroad rolling stock were permitted to have their own way about the selection of metal for bearings and of the lubricants to be employed in keeping them cool, there would be very little trouble with hot boxes. We notice that on most of the roads where hot boxes are chronic, varied by epidemics of the malady, the mechanical department have little influence in the character of the supplies purchased. A most unfair thing about this trouble is that the mechanical men are nearly always blamed for the recurrence of hot boxes. No end of ingenuity is devoted to imagining far-fetched causes for the difficulty, when the real cause is on the surface. —*Locomotive Engineering.*

Early American Steel Rules.

BY AMBROSE WEBSTER.

The machinist of to day who is using the fine Brown & Sharpe steel scales and micrometer calipers has little conception of the difficulties of making accurate measurements which confronted the machinist of 1840.

When the writer commenced his term of four years' apprenticeship, there were no steel scales in the market, and we were obliged to set our calipers to the proper dimensions by laying them on an ordinary boxwood rule; trying to have the ends of the caliper coincide with the division lines. It was utterly impossible, of course, to secure uniform measurements in this way, and even as late as 1857 there were, in the machine shop of the American Watch Company, four different sizes of "standard" ¼-inch taps.

In 1848 there were, in the Springfield Armory, some home or hand-made steel scales, graduated on a device consisting of a wooden slide to which the scales were clamped, this slide being moved by a screw on which was a wooden index, to the periphery of which was tacked a ribbon of paper on which the proper graduations were spaced with dividers. The engravings, Figs. 1 and 2, show a scale made by the writer in 1851.

Previous to this date Mr. S. W. Putnam, of Fitchburg, Mass., had done something in this line, and at Figs. 3 and 4 a scale is shown made by him in 1836. Mr. Putnam evidently desired to get a great range of subdivisions (ranging from 8 to 34 to the inch) and as quarters of an inch were indicated by long lines, it seemed to him to be advisable to use these long lines or "quarters" in all the graduations of an inch. Consequently the number of divisions in these "quarters" varies somewhat; as, in the case of the division of 14, there are two "quarters" containing four divisions and two containing three divisions each. The term "quarters" is not correct, but we naturally drift into the use of that term.

Mr. Charles L. Hildreth, superintendent of the Lowell Machine Shop, writes:

"The original standard unit of length, adopted by the Lowell Machine Shop in 1824 for use in the construction of machinery, is the English foot, according to a brass standard made by Cary, of London, and preserved with care in the safe of the proprietors of the locks and canals on Merrimack River. This scale is undated, but has marked upon it 'Cary, London, Farenheit, 62 degrees.' This is the brass standard measure referred to by James B. Francis, in his celebrated work entitled 'Lowell Hydraulic Experiments.' From 1824 to 1835 it was impracticable for the workmen employed at these shops to readily procure scales and rules for measuring lengths, which scales and rules were in exact accord with one another. One of our superior mechanics, Samuel Brown, made in 1835 a standard screw for use in graduating measuring scales. This screw was made to agree with the standard brass scale of Cary, of London, and it took nearly a year to perfect it. Mr. Brown then made two short duplicate standard screws for use in graduating small scales. Mr. W. D. Blanchard has now in his possession a steel scale 4 inches long, which he graduated about 1846 by the aid of one of the standard screws which had been made by Samuel Brown. He also in 1847 or 1848 graduated a scale 24 inches long by the same standard screw."

Mr. Hildreth also writes:

"The Lowell Machine Shop made standard scales long before they were undertaken to be manufactured in Bangor."

Mr. Joseph Brown, of the firm of Brown & Sharpe, Providence, R. I., commenced the manufacture of steel rules and scales and vernier calipers in the year 1850, and the first printed circular with price list was issued March 1, 1851. The following is a copy of the first circular issued by him:

U. S. STANDARD RULES.
Manufactured by
JOSEPH R. BROWN.
115 South Main St., Providence, R. I.

The subscriber has recently invented and put into operation a machine for dividing rules and scales of all descriptions, in the most accurate manner. Having been convinced by long experience that it is impracticable to make a screw sufficiently accurate to be used in a dividing engine, he has constructed a machine upon an entirely new principle which, he is happy to say, produces the most satisfactory results. It is operated entirely by power, which renders it automatic, thereby obviating the imperfections arising from the employment of hand labor.

The attention of engineers, machinists, draftsmen, and all others wanting a very accurate instrument, is respectfully invited to these rules.

As they are the first American article of the kind produced, the maker solicits for them a share of public patronage, and he pledges himself in every instance to give entire satisfaction.

N. B. *Scales and rules of any number of divisions graduated to order.*

JOSEPH R. BROWN,
115 South Main St.,
Providence, R. I.

March 1, 1851.

In 1852, Samuel Darling and Edward H. Bailey began the manufacture of steel rules in Bangor, Me. This partnership continued a year, then Mr. Darling purchased Mr. Bailey's interest and took another partner named Michael Schwartz, and continued the business under the name of Darling & Schwartz until 1866, when the firm was dissolved, and Mr. Darling formed a partnership with Joseph R. Brown and Lucien Sharpe, under the name of Darling, Brown & Sharpe, and soon moved the works to Providence, R. I.

The difficulty of making smooth, even marks on steel was a serious one, and there is a story that in a conversation between Mr. Brown and Mr. Darling, Mr. Brown remarked upon the difficulty of keeping a good cutting point on the diamonds. Mr. Darling seized this information, and at once adopted diamonds for marking his scales, but in regard to this story

> "I cannot say what the truth may be,
> I say the tale as 'twas said to me."

In the early manufacture of scales it was perfectly natural to resort to a screw for feeding the carriage, but Mr. Brown's mechanical genius led him to see the difficulties of making a perfect screw, and he resorted to another process for moving the carriage, which was for a long time a secret, and still may be one, as the graduating machine of Brown & Sharpe is rarely or never shown to visitors. The writer, however, made a "bad break" during one of his visits to Brown & Sharpe's establishment, when Mr. Brown was kindly showing him about, by saying, "I have not yet seen the machine for dividing scales." Mr. Brown looked up over his glasses very pertly, saying, "I am sorry you alluded to that. I should like to show it to you, but we never do show it, but," turning upon his heel and opening a door at his left, "I will let you look at it a moment." The "moment" was so short that I saw but little of it.

Among the many things which have led to the development of the present high skill and precision in machine shops, I consider that steel scales and micrometer calipers stand in the first rank.

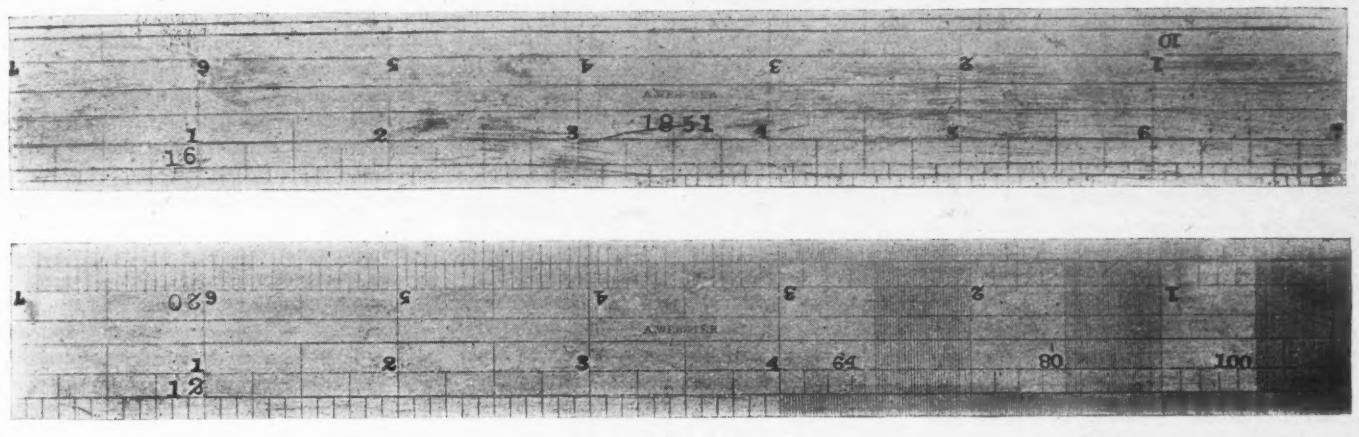


Fig. 1.

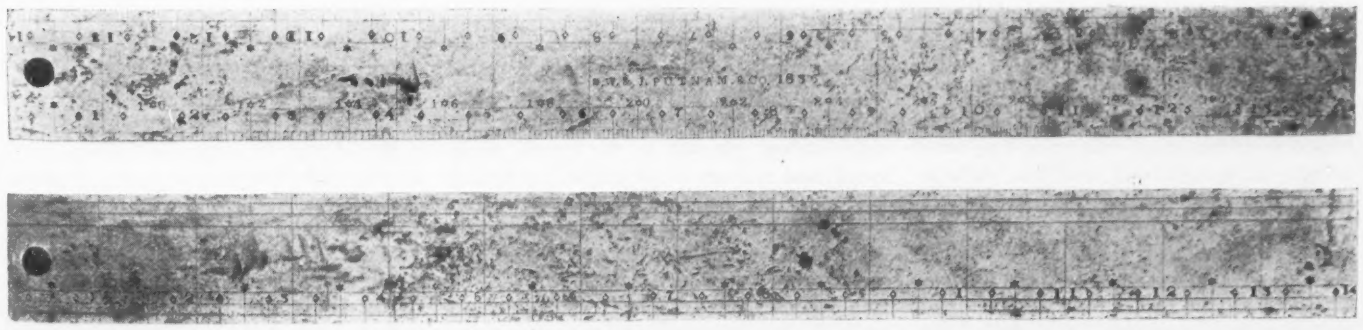


Fig. 2.

The fast new British naval vessel which we mentioned a week or two ago as having made a speed of 28.33 knots on her trial trip, which is equal to about 32¾ miles per hour, has a displacement of 220 tons and an estimated horse-power of 6.248, which gives her 28.4 horse-power per ton of displacement. Some of the small aquatic racing machines about New York harbor have about 50 horse-power per ton of displacement, though none that we know of have attained over 30 miles per hour. The large transatlantic liners, "Paris" and "New York," have about two horse-power per ton of displacement.

All the while, in European countries, agitation in favor of improving the waterways goes on. Just now in England the improvement of the River Trent is under consideration. For certain classes of traffic water transportation is so far superior to transportation by rail as to scarcely make it worth the while to mention both together. Every dollar judiciously expended for improvement in waterways means ten dollars in the interests of the country.

AMERICAN MACHINIST

Communications relating to the reading columns should be addressed to the Editor. All other communications should be addressed:

AMERICAN MACHINIST,
203 BROADWAY, NEW YORK.

PUBLISHED WEEKLY AT
203 Broadway, New York.

Horace B. Miller, Pres't and Bus. Manager.
Lycurgus B. Moore, Treas. and Sec'y.

F. F. Hemenway, Editor and Mech. Engineer.
J. G. A. Meyer, } Associates.
Fred J. Miller, }

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$4.00 a year to Other Countries, postage prepaid.

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Transient, 35c. per line, each insertion.
"Business Specials," 50c. a line.
No Commission allowed to advertising agents except on existing business.

The American News Company,
Publishers' Agents, New York.
DEALERS SUPPLIED BY
The Albany News Company, Albany, N. Y.
The American News Company, New York, N. Y.
The Baltimore News Company, Baltimore, Md.
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Subscriptions received in Paris, France, by E. Terquem, 31 Boulevard Hausmann, at 21 francs per annum, postpaid.

Subscriptions received in Australia by W. Williams, 17 and 21 Fink's Buildings, Melbourne.

NEW YORK, APRIL 12, 1894.

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Monthly Meetings of the A. S. M. E.

The question of holding monthly meetings of the A. S. M. E. is, it seems quite likely, to come up in some form, and it is not improbable that members of the society may be asked for an expression of opinion regarding the advisability of such meetings to commence next winter and to take the place of the informal and unofficial meetings which are now being so successfully conducted as a result chiefly of the interest and energetic work of Mr. M. N. Forney, who has devoted much time and some money to the work of arousing an interest and securing interested attendance at the meetings, and, whether these meetings are to be made official or not, will, we think, always be accorded the credit of their successful inauguration.

The American Institute of Electrical Engineers, which for some time past has been holding regular monthly meetings in New York, has been having some experience in this line and has found a very strong demand for similar official meetings in other cities where numbers of members could attend who can not attend the meetings in New York. And it has been intimated that the institute might consent to the conduct of such meetings, or face the alternative of having a number of rival organizations, which would, of course, divide the membership and what may be called the association energies of the general body of electrical engineers. The same problem may present itself to the A. S. M. E., for probably there is a sufficient membership in and around San Francisco, Hartford, New Haven, Washington, Chicago, Boston, Worcester, Detroit, St. Louis, Syracuse, Cincinnati, Cleveland, Erie, Philadelphia, Pittsburgh and Providence to support such meetings during the winter. If the plan advocated by Mr. Pope (Secretary of the American Institute of Electrical Engineers) were followed meetings might be held in all these places simultaneously with the one held in New York; all to discuss the same subject and the reports of all the meetings to be collated for publication in the Transactions; repetitions being, of course, omitted.

This would, undoubtedly, very much increase the bulk and expense of publishing the transactions, though this might be—as is claimed—more than offset by increased membership and receipts therefrom.

Much speculation might be indulged in regarding the effect upon the society of adopting some such plan, but it would be nothing more than speculation, and an expression of opinion or the desires of members with regard to the matter would be of much greater value.

Human Nature.

A correspondent in this issue, who for reasons of his own veils his identity under the signature of "Presto," raises some points that are well worth consideration. Human nature is the hardest thing in the world to deal with, and when properly handled is one of the most potent factors in any kind of enterprise. Great battles have been lost because generals, great in other respects, have shown lamentable defect in dealing with human nature. For the same reason manufacturing enterprise has often failed. It is a difficult question, perhaps, to decide just to what extent a man employed in a manufacturing establishment should be considered as a mere machine, or a sentient being; to decide just how far what he can do in the way of producing certain parts of machines, or his knowledge of how certain parts of machines can be best produced should be utilized. It is an easy thing to make a machine of a man, never taking into account the fact that he can do something more than the machine, and it is just as easy to consider that he may be able to think to advantage, sometimes. But there is no doubt that the way he is considered in this respect will influence the work he does. It is a matter worthy of a good deal of consideration whether or not one man knows enough, say in a mechanical line, to direct and dominate every thing that need be done in the various mechanical operations, or whether the man at the head is the better for, occasionally, relying upon the judgment of a man whose entire education has been such as ought to give him special knowledge.

Without prejudicing the question, we ask our readers to give attention to the article named.

When foundrymen meet together nowadays for discussion the question of chemistry is pretty sure to come to the front. Middle-aged men can remember the time when such a thing would result in nothing more serious than laughter. Foundry work has pushed to the front in a remarkable manner during the past fifteen years, and its influence on modern industrial methods is important. The rough, unshapely casting of a few years ago has given way to the work of art in the iron foundry, and the strength of castings from that most common of products—pig-iron—has been increased most materially. This increase in strength of castings will undoubtedly continue, but it will come in a great degree from the better understanding of just what they are making by the manufacturers of the raw material—the pig-iron. To suit the conveniences of trade there must always be scattered here and there throughout the land little foundries, pouring once or twice a week. Such a foundry cannot pay five or more thousand dollars a year for the services of a chemist. They must be able to buy iron that with certain plain conditions fulfilled will produce reasonably definite results. All reason seems to point to this outcome of the whole matter. The chemistry will have in the main to be supplied by the blast furnace, and the foundry must be able to buy iron from the use of which they will be able to guarantee certain qualities in castings. In connection with this thought, if not exactly in line with it, we refer our readers to the article by Mr. Keep printed elsewhere in this issue.

The fact that after years of experience in counterbalancing engines in locomotive practice, the matter is far from being settled, would rather rationally lead to the conclusion that there was something to be learned in regard to counterbalancing generally. It is impossible for a force to act *instantly*—there is no such thing as instantly in mechanics—and perhaps the counterbalance is not properly placed. However this may be, we believe that in high-speed engineering the whole matter of counterbalancing is tentative—a little more or less makes the engine run about right, and a little more or less goes. Perhaps putting the counterbalance a little further ahead or behind might produce better results, but the exact location would, in all probability, be so controlled by spring of parts and conditions of rigidity that just what to do with it must be determined by trial. It is rather evident that there is more in counterbalancing a steam engine than has been dreamed of, in philosophy.

As between the trolley and cable propulsion for steel cars the public seems to be between the devil and the deep sea. The cable car—as frequently exemplified in New York—takes the bit in its mouth, so to speak, and refuses to be controlled by any efforts of the gripman to that end. But there is this advantage: the car can go no faster than the cable, although the matter usually concludes by smashing up one or two vehicles, more or less, the drivers of which labor under the impression that the car can be stopped at will. On the other hand, the trolley car rushes along under the influence of the time table, frequently at speeds that work death to pedestrians. Of the two it seems pretty fairly well settled that the trolley car claims the most victims.

If one wants to know how establishments which put in such large hammers and hydraulic forging machines as have been erected in a few works within the past few years can hope to "get their money out of it," he may consider that the forgings for an 8 inch gun weighing, say, 40,000 pounds are paid for by the government at something over 27 cents a pound, while those for a 12-inch gun weighing in the rough 138,732 pounds cost still more per pound—a little over 30 cents. Of course, we are not saying that this is too much, but those who are furnishing ordinary forgings to be used in machine construction will be apt to consider it a good price.

Athletic sports have wonderfully widened the field of possible usefulness of the modern college graduate, which it must be admitted has been a little narrowed by the general diffusion of knowledge through the excellent and ever-improving public schools of this country. If the college graduate does not find much in the way of Greek and Latin to fall back on he has still rowing and boxing and baseball—especially baseball—left. A pitcher or a catcher, or a some-kind-of a-fielder that comes from Yale or Harvard, has a patent advantage—and this cannot be denied—over an ordinary mortal who has nothing of the drawing card in his make-up. The great institutions of learning of the country are not likely to get left in this matter.

Personal.

On the 29th ult., Mr. Alfred Betts, who has been president of the Betts Machine Co. since its organization fifteen years ago, retired from the active management of its affairs, and his son, Mr. William Betts, who has also been previously connected with the establishment, was elected president of the company. We understand that Mr. Betts, Senior, will retain his interest in the business, but will take a little more time for the enjoyment of the results of his many years of application and hard work.

The city authorities of Chicago produce figures to show that they can make and deliver gas to the citizens at 80 cents, and cover into the city treasury $2,000,000 a year in the transaction. By and by those who dwell in cities will find out what great frauds the gas companies really are. Taken at an average, the residents of cities in this country are paying twice as much for gas as they should pay, yet when anything is said against such extortion it is called "howling" or something equivalent.

The *Ironmonger* holds that there should be, in every county, a combination against the articles produced by the prison-labor contract system and sold in competition with the products of free labor. We heartily indorse all this. It has been our contention for years that prison labor should not be brought into competition with free labor. The tendency of doing this is to fill the prisons, which, we think, has been rather clearly shown in some parts of the country.

English manufacturers seem to have got awake to the fact that edge tools—axes and the like—were made in this country materially cheaper than in England. The result is, so we are told, that machinery is being largely brought into service there for such manufactur[illegible].

Mr. Henry A. House, a well-known mechanic and inventor, formerly of Bridgeport, Conn., but now located at East Cowes, Isle of Wight, is here for a short time on business connected with an English company, which has been formed to push some of his inventions in the line of fast steam yachts and their equipment.

For several years past and until recently Mr. House has been connected as engineer and inventor with the work carried on in England by Maxim in devising a flying machine.

By Mr. House's new system of construction and using a new oil burner, water-tube boiler and engine—all his inventions—he has built small twin-screw yachts having 75 horse-power per ton of displacement, and with these has attained some hitherto unheard of speeds.

Edward Barry Wall, assistant to the General Manager of the Pennsylvania Railroad, died as the result of an operation for apendicitis, April 1st. Mr. Wall was born in 1856, and, although a young man at the time of his death, had already attained prominence in railroad circles and was of very great ability. Mr. Wall was graduated from Stevens Institute in 1876 and was a member of the Master Mechanics' Association and of the American Society of Mechanical Engineers.

Questions and Answers.

Questions of general interest relating to subjects discussed in our columns will receive attention in this department. The writer's name and address should always accompany the question. Neither correct initials nor location will be published when there is a request to that effect. If questions are enclosed with a business communication, they should be written on a separate sheet.

(175) W. M. W., Philadelphia, writes: Kindly favor me with a receipt of oil for burning in lamps without a chimney—something which will burn without caking; the wick is specially desirable. *A.*—Lard or whale oil will answer your purpose without further preparation.

(176) N. E. L., Austin, Ill., asks: Are there any speed indicators made that will show automatically at sight the rate of speed? The indicator whose reading must be compared with the observed time is, of course, excluded. *A.*—There are such indicators made, and can be procured from dealers in machinists' tools, or from makers of measuring machines; the addresses of some of these are given in our advertising columns.

(177) J. J. G., Toledo, O., writes: Please state if it is customary to employ boys in manufacturing establishments to oil shafting and machinery. *A.*—Boys sometimes do this kind of work, but it is not customary. We do not advocate the practice. 2. Is the use of a torch to enable the oiler to see at night or in dark places in the daytime common? *A.*—The use of the torch is common in places where it cannot do any damage or where there is no danger from using it. There are establishments where the use of the torch would not be permitted under any circumstances.

(178) S. E, Fargo, North Dakota, writes: Kindly inform me what would be the difference in heating value of steam at 5 pounds, and steam at 25 pounds pressure in radiators. Would the increased pressure furnish sufficient heat to the radiators to warrant its maintenance? *A.*—If the temperature is reduced to that of water at atmospheric pressure, the units of heat given off by the steam at 5 pounds pressure will be 970, and that given off by steam at 25 pounds pressure will be 983. The difference is so small that it will not be economical to maintain the pressure at 25 pounds.

(179) W. W. G., Philadelphia, Pa., writes: There are two tanks, a large and a small one, some distance apart and connected by a pipe fastened to the bottom of each tank. Will the water in the large tank force the water above its own level in the smaller one? *A.*—No; the water will maintain the same level in both tanks. 2. If the water is drawn in small quantities, say, a pint or a quart at a time, through a faucet at the lowest point in the connecting pipe, will the water in both tanks be at the same level after the faucet is closed, and will the water level be maintained until all the water is drawn out? *A.*—The water level will be maintained.

(180) J. H. A., Brooklyn, N. Y., asks: Are there any books published especially adapted to the designing, manufacturing and running of sugar machinery? *A.*—The only book we know of which treats on this subject is "Sugar Machinery, Including the Process of Producing Sugar from the Cane," by N. P. Burgh. It was published in 1871, price $10. We would advise you to examine it before buying. 2. Have you at any time published any information in regard to this subject? If so, kindly state numbers. *A.*—"Diffusion Battery for the Extraction of Sugar from Sugar Cane," July 23, 1887. "Sugar Cane Cutter and Crusher," April 8, 1890.

(181) E. J. B., ———, writes: Please tell me the amount of clearance there should be on the cutting edges of twist drills of all sizes, the drills to be ground to an angle of 60 degrees. *A.*—We think there is no uniformity of practice in this matter. The lips of drills must, of course, have a certain minimum amount of clearance in order to enable them to cut at all. When a drill is at work and is being fed continuously, the bottom of the hole is part of what may be called a double helix, the angle of which depends for any given drill upon the rate at which it is fed, *i. e.*, the amount of feed per revolution. The angle of clearance must be somewhat greater than this, but in our opinion should not be much greater. Probably 3 degrees to 5 degrees is about right. 2. Where can I purchase a good book on blue printing? *A.*—We do not know of any such book, and do not see how much of a book could be made out of that subject. More information about blue printing has been published in our own columns than is to be found elsewhere, we think.

(182) W. F. B., Little Falls, N. Y., writes: Please give me the size of drills used for different taps. *A.*—The size of drill for a full V-thread is found by dividing 1.733 by the number of threads per inch, and subtracting the quotient thus obtained from the outside diameter of the tap, the result will be the size of drill required. Or in symbols we have

$$t - \frac{1.733}{n} = s,$$

in which t = outside diameter of tap, n = number of threads per inch, and s = size of drill. For the U. S. standard thread divide 1.3 by the number of threads per inch and subtract the quotient from the outer diameter of tap, the result will be the size of drill required. Or

$$t - \frac{1.3}{n} = s,$$

in which the symbols denote the same quantities as before. The following example will show the application of these rules. Find the size of drill for a $\frac{7}{8}$ tap, 9 threads per inch, full V-thread.

$$\tfrac{7}{8} - \frac{1.733}{9} = .683, \text{ say } \tfrac{11}{16} \text{ inch}$$

for the size of drill. For a U. S. standard thread we have

$$\tfrac{7}{8} - \frac{1.3}{9} = .731, \text{ say } \tfrac{3}{4} \text{ inch}$$

for the size of drill.

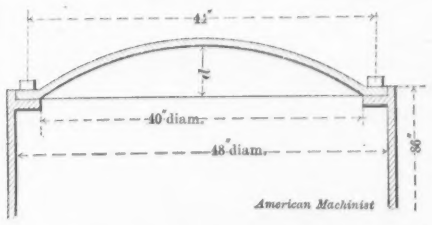
(183) F. W. C, Lawrence, Mass., writes: Kindly solve the following problems: What should be the thickness of the shell, flange, and head of the dryer shown in the accompanying sketch for a steam pressure of 75 pounds per square inch. Please give formulas by which you work out examples of this kind, so that I can use them for similar cases? *A.*—You do not state the kind of material of which the dryer is to be made: but from the general design indicated by the drawing we assume that it is to be made of cast-iron. For the purpose of computing the thickness of the head to resist the steam pressure only we should change or modify the form of the head a little and assume it to be of the form as shown in the illustration. The thickness of the head under these conditions is found by the following formula:

$$t = \frac{P\,(R^2 + d^2)}{4 \times S \times d},$$

in which t = thickness of head in inches, R = radius of head to the center of bolts, d = height of the arc, P = steam pressure per square inch, S a safe tensile stress of cast-iron, for which we shall take a value of 2,500 pounds per square inch. If now, d is 7 inches, we have,

$$t = \frac{75 \times (22^2 + 7^2)}{4 \times 2{,}500 \times 7} = 0.57 \text{ inch.}$$

This thickness will resist the steam pressure, provided the casting is sound. Your drawing seems to indicate that this dryer revolves on journals cast to the heads, if so the heads will be subjected to an additional



stress which may be intensified by the water due to condensation in the dryer. Under these conditions we should make the head twice as thick as found above, say, $1\frac{1}{2}$ inches, or put stiff ribs inside. The thickness of shell to resist the steam pressure is found by the following formula:

$$t = \frac{P \times R}{2{,}500},$$

in which t = thickness of shell in inches, P = steam pressure per square inch, R = inside radius of shell, and the constant 2,500 is the safe tensile strength of cast-iron adopted for this particular case, hence we have,

$$t = \frac{75 \times 24}{2{,}500} = 0.72 \text{ inch}$$

for the thickness of shell to resist the steam pressure. The thickness of flange should be $\frac{3}{8}$ inch greater than that of the shell, this gives us practically $1\frac{1}{2}$ inches for the thickness of flange. The flange on the head should be of the same thickness. 2. How many tap bolts should be used in the head? The bolts are $\frac{7}{8}$ inch outside diameter, and $\frac{3}{4}$ inch diameter at the bottom of the thread. *A.*—Assuming the inside diameter of the flange to be 40 inches, then the total steam pressure on the head will be equal to the area of a circle 40 inches diameter multiplied by the steam pressure per square inch. The area of a circle 40 inches diameter is 1,256.6 square inches, hence the total pressure on the head will be,

$$1{,}256.6 \times 75 = 94{,}245 \text{ pounds.}$$

This pressure the bolts must resist. The stress per square inch of bolt should not exceed 5,000 pounds, hence the aggregate area of the bolts will be,

$$\frac{94\,245}{5{,}000} = 18\,8 \text{ square inches.}$$

The cross sectional area at the bottom of the thread of the bolt is .44 square inch, and therefore the number of bolts required will be:

$$\frac{18\,8}{.44} = 42 \text{ bolts.}$$

In our opinion it is very dangerous practice to make this dryer out of cast-iron, as this metal is very treacherous when subjected to a tensile stress. We should make the whole of steel, which will reduce the weight and be far safer than when made of cast-iron. If it is to be made of steel the same rules as given above may be used, with this difference: that for the safe tensile strength of cast iron substitute that of steel which may be taken at 12,000 pounds per square inch. 3. Do you publish any books that give information on this and kindred subjects? *A.*—We do not publish books of any kind.

Business Specials

Transient Advertisements 50 cents a line for each insertion under this head. About seven words make a line. Copy should be sent to reach us not later than Saturday morning for the ensuing week's issue.

Grant's Gears, Lex'n, Mass., & Phila, Pa. See p. 12.

Forming Lathes, Mer. Mach. Tool Co., Meriden, Ct.

Milling Machs. Kempsmith M. T. Co., Mill., Wis.

Turret Drills, 6 spindles. A. D. Quint, Hartford, Ct.

"National" Lathe Chucks. Best made, page 15.

Speed Gage McLauthlin & Co., Fulton St., Boston.

Pattern and Brand Letters. A variety of sizes and styles. Heber Wells, 8 Spruce St., New York.

Davis Key Seating Machines kept in stock by Manning, Maxwell & Moore, 111 Liberty St. N. Y.

Selden Packing for stuffing box, with or without rubber core. Randolph Brandt, 38 Cortlandt St., N.Y.

Pulley lathes, most efficient offered. The Lodge & Shipley Machine Tool Co., Cincinnati, O.

Engine Castings, 1 to 6 Horse-power Vertical. Humphrey's Foundry, Bellefontaine, O.

Best Presses and Dies for all sheet metal work. Ferracute Machine Company, Bridgeton, N. J.

Air Compressors for every possible duty. Clayton Air Compressor Works, 26 Cortlandt street, N. Y.

Steam Pressure Regulators, Reducing Valves, Safety Checks. Foster Engineer'g Co., Newark, N.J.

M. E. Howard, Indianapolis, Ind. Specialty, 4 and 8 H. P. engines in stock, write for price.

Sheet metal tools & light mach'y, imp'd, cheapened & mfg'd. Prac. Mach. Co., Bridgeton, N. J.

Guild & Garrison, Brooklyn, N. Y., manufacture steam pumps, vacuum pumps, vacuum apparatus, air pumps, acid blowers, filter press pumps, etc.

Split Pulleys at low prices, and of same strength and appearance as Whole Pulleys. Yocum & Son's Shafting Works, Drinker St., Philadelphia, Pa.

Easy lettering, Cromwell, post free, 50 cents, lists free. Spon & Chamberlain, 12 Cortlandt street, New York.

Improved Duplex and Special Gear Cutters in stock and to order; Gear and Milling Cutters of all descriptions. R. M. Clough, Tolland, Conn.

"Pumping Machinery." New book, 450 pp. 8vo, 270 Eng. Prospectus free. W. M. Barr, 3223 Powelton avenue, Philadelphia, Pa.

American Packing Rings make pistons steam tight. Are simple, durable and inexpensive; write for circular. J. H. Dunbar, Youngstown, O.

New Jersey Art Metal Co., Passaic, N. J., finest thin and ornamental castings in brass, bronze, aluminum, etc.; machinery name plates in brass and aluminum.

Grinders' Supplies—Emery, Emery Wheels, Grinders, Knife Powders and Sharpeners, Paste & Liquid Polish, Whetstones. The Tanite Co. New York, N Y.; Cincinnati, O., & Stroudsburg, Pa.

"Binders" for the AMERICAN MACHINIST. Two styles, the "Common Sense," as heretofore sold by us and mailed to any address at $1.00 each, and the "New Handy," mailed at 50c. each. The former has stiff board covers, while the latter has flexible covers with full page opening flat. Either will hold the entire 52 issues of any volume. AMERICAN MACHINIST PUBLISHING CO., 203 Broadway, New York.

"Indicator Practice and Steam Engine Economy." By F. F. Hemenway. Contains plain directions for using the indicator and making all required calculations from the diagram, also the principles of economy in operating steam engines and current practice in testing engines and boilers. Price, $2 post paid. Published by John Wiley & Sons, 53 East Tenth street, New York.

Foundry Mixtures Controlled by a Mechanical Analysis.*

By W. J. KEEP, DETROIT.

It seems that a chemist cannot give a formula for the chemical composition of a casting that shall have a specified strength, shrinkage and chill, unless he can first analyze a casting that has such physical qualities.—[Mr. Fry, at last meeting.]

The expression, "a physical test," seems to be universally understood to mean a test for strength, using a test bar having one or more inches cross-section. I have used this expression, not wishing, during this discussion, to speak of my special methods; but that what I say may be understood, I must describe them as briefly as I can.

"*Keep's Test.*"—A test bar, very sensitive to change in both chemical and physical composition, $\frac{1}{2}$-inch square and 12 inches long, is cast in green sand, along with a still more sensitive companion bar, one inch wide, $\frac{1}{10}$ inch thick, and one foot long.

These bars are cast with their ends against chills $12\frac{1}{2}$ inches apart. The distance that the ends of these test bars draw away from these chills, gives the shrinkage in thousandths of an inch per foot.

The foundry mixture is governed by this record of shrinkage, which tells whether there is enough or too much silicon in the casting. If the shrinkage is not as low as has been found best for such castings, increase the irons that are high in silicon; and if the shrinkage is too low, increase the low grade irons or scrap. This mechanical analysis takes into account the influence of all elements in the iron, for if carbon is low, it requires more silicon to produce a given effect, and *vice versa*. If any condition increases shrinkage, more silicon is needed to bring it down. What the founder wants to know, and to know it quick and sure, is whether he has the right amount of silicon in his casting. The shrinkage tells him at once. It also indicates hardness, for the two rise and fall together. By splitting the end of the square bar, the depth of chill is measured, which is an additional guide. The grain of the fracture of the test bar tells an intelligent foundryman whether a casting of a certain size will be spongy or too close. Four other $\frac{1}{2}$-inch square bars are cast at the same time. These five square bars are broken in a special testing machine, which makes an autographic record of strength, deflection, set and elasticity, and the average of these five is the record.

Relative tests are those which are applicable to every case. The routine must be the same in all tests, and any test record of any iron or casting is greater or less than other tests by the same method. It is soon found what test record accompanies acceptable castings for any purpose, and this record at once becomes the standard record for such castings in that foundry, though it may not correspond to results obtained by others. Having determined what is the most satisfactory shrinkage for each grade of casting, the endeavor thereafter is to keep as close as possible to the standard.

The record of the sensitive half-inch test bar is the unit of measure for any mixture, the same as a foot rule is a measure for the smallest or greatest variation in size. Strength generally cannot be traced directly to chemical constitution, or to shrinkage, but is dependent on the mechanical structure of the metal, and the test of strength is to find if we have made a mixture that brings out the greatest strength.

Keep's Foundry Chemistry.—My reason for giving this name to my conclusions regarding the chemical elements found in cast-iron, was to draw attention to the radical difference between them and the opinions of the average chemist, as stated in works on iron metallurgy. For twenty years I was a close student of metallurgical chemistry, in charge of foundry work, and failed to find a relation between the chemical composition and the strength of test bars of various shapes. Mr. Mumford had a similar experience.

* Prepared for the meeting of the Foundrymen's Association, at Philadelphia, Wednesday, April 4, 1894.

When I hit on a half-inch test bar as a test for shrinkage, I found a solution of the whole question, and found that silicon, the controlling agent of the mixture, was indicated by shrinkage.

But no physical characteristic corresponded to either of the carbons, or to phosphorus, sulphur, or manganese. In 1885 Professor Turner hit on the use of a series of test bars, with silicon the only variable. I at once applied the same method to all of the chemical elements, and found the exact influence of each when in cast iron. I found, also, that in the quantities usually found in pig-iron, or in gray foundry castings, the influence of all but silicon was almost imperceptible, and that all but silicon, in ordinary practice, could be overlooked. In this light, each iron analysis is in perfect accord with physical tests of all kinds, and mystery and superstition are banished from iron mixture.

Proof of My Position.—As chemists either dislike, or are not familiar with my mechanical analysis, I will go back to laboratory methods for my proof. Within a few weeks, the Tennessee Coal, Iron and Railroad Co. have sent me a pig of each of the eleven grades of iron made at their furnaces, the same mixture of ores being in each pig. Each pig contained the hole from which their chemist, Dr. Phillips, took his drillings. I made a set of test bars from each, and the chemical and physical records are Series I.

Mr. A. J. Morse, now instructor in metallurgy in the School of Mines, Rapid City, S. D., sent me, about the same time, fourteen pigs, with the drilled holes in them. As he had completed the graphic carbons in only six, I make of these Series II.

Several years ago, a foundry on the Hudson River procured a complete analysis of the irons entering into their mixture, and of the castings, and sent the pigs and castings, with analyses, to me. These are Series III.

I have arranged all of the above irons in the order of their silicons.

Series IV is composed of tests of a single mixture of cupola iron, melted with coke, taken a week apart. Tests 788 and 791 were the very first and last iron taken from the cupola, to determine the influence of a cold and a hot cupola. Tests 780 and 782 were cast 1½ minutes apart, from one ladle, the iron being stirred with a steel bar between casts. Tests 784 and 787 were cast 2½ minutes apart, the iron being allowed to stand quietly between casts. The full test records can be seen in Series VII. The test bar 782 is the strong bar for which I challenged a prescription, and now that I have given the analysis, Mr. Fry can possibly tell what his prescription should be, but the same result can be obtained with almost any other composition, when the percentages of silicon, phosphorus, sulphur, and manganese are less. Series IV is produced to show all who have held a different opinion, that the physical qualities of a casting cannot be produced by a chemical formula alone, but that a test of the right kind will tell when the mixture is such as to produce the most desirable physical structure.

The cupola charge was 1,800 pounds coal on bed; the charge of iron was 4,000 pounds, and of coal, 300 pounds, etc.; the melt was 16 tons, and they did not slag the cupola. (Each iron charge was 1,000 pounds Bushong, 250 pounds each 1 and 2 Poughkeepsie, 500 pounds each Alice and Franklin, 250 pounds Globe, and 1,250 pounds of re-melt.)

To be certain that the determinations of Series IV were absolutely correct, we sent the iron to Messrs. Cary & Moore, of Chicago, asking them to make the analyses in triplicate. The analyses are of the same bars of which the physical record is given. The averages are given in Series VII to IX.

In examining these series the records of the whole must be considered to draw conclusions.

Manganese.—These series do not indicate any influence from the presence of this metalloid, and I have proved in my paper, "Manganese in Cast-iron" (Transactions Am. Inst. Mining Engineers, vol. xx, p. 291, 1891), that it need not be feared when it is below 1 per cent. in the casting, and that it can be ignored. When above 1 per cent., it increases shrinkage and hardness, but it does not increase combined carbon. It does not turn iron white or increase a tendency to chill.

Phosphorus, in these series, gives no indication of any influence on the physical qualities of the iron. I have proved in my paper, "Phosphorus in Cast-iron" (Trans. A. I. M. E., vol. xviii, p. 450, 1889) that this metalloid in cast-iron has no effect on carbon; that it decreases shrinkage, and adds some life to molten iron. It weakens cast-iron when much over 1 per cent. American pig-iron will rarely impart to castings more than this percentage, and for this reason it may be ignored.

Sulphur.—We now come to the element which many claim to be poison. We have high sulphur in five of the irons in Series I, but in these irons it has absolutely no influence on dead-load strength. Perhaps it has a slight influence on impact strength. We might infer that it increased chill, but the gray forge, which is one of the highest in sulphur, and which is low in carbon, has absolutely no chill.

In Series IV, the iron mixture is the same in all. The chemical composition is the same in all (except 788), except that sulphur and silicon vary slightly. If any one claims that the small variation in sulphur has produced any physical change, they are met by tests 784 and 787, where the highest sulphur is in the latter, but with absolutely no physical variation, except for the better. The more sensitive flat test bar shows decreased shrinkage, and the strength is increased 25 per cent. In all of the irons of Series I and IV, the increase in sulphur and the change in physical character was due to a cold furnace or cupola. Test 788 was taken from the cupola when it first began to melt, and was comparatively cold. There was no slag to cover the iron, and the cold blast reached all parts, and gave the iron considerable chill, allowed quite a percentage of carbon to remain combined, and gave the iron a high shrinkage. It was not the sulphur that did this, because 787, the last iron taken from the cupola, has also substantially the same sulphur, with the lowest shrinkage and less than half the chill. All that produced this change was the heat, for silicon is less in 787. On that day a sulphury car of coke was used. Sulphur is accompanied by slate, which means increased ash, that is deficient in heat-producing power, and this caused the cupola to melt cold.

In Series I it was probably some chilling influence in the furnace that gave the close grain to the foundry forge, and not low silicon, and this allowed sulphur to remain, and it also gave the iron a chill. The same was true of the No. 3 foundry. The gray forge got its close grain from a lack of carbon and low silicon. We have in this almost 0.2 per cent. sulphur, and absolutely no chill.

In my paper, "Sulphur in Cast-iron" (Engineering Congress, Chicago, 1893), I show that in tests where sulphur is higher than one-half of one per cent., chill is increased, but there is no indication anywhere that sulphur is in any way beneficial. To melt iron hot the fuel should be reasonably free from sulphur. Pig-iron with a good grain will be low in sulphur.

The amount of sulphur in gray iron castings made from merchantable pig-iron will be so low in sulphur that it will exert no perceptible influence, and can be ignored. Chemists are very apt to blame sulphur for anything that is mysterious. One, at your last meeting, related that he told a New York founder that 1 per cent. of sulphur in his fuel had added 0.15 per cent. of sulphur to his casting, and that this had turned the iron white. The poor fuel melted cold, but he acknowledges that he did not know the carbon in the pig, and he does not seem to know that if he had prescribed an increase of silicon, the castings would have been gray and soft. No analysis was necessary, for the white fracture indicated that silicon was needed. If sulphur should exert any influence, a slight increase of silicon would at once remove the influence.

I am told that for malleable iron castings, for chilled castings, especially where they are subjected to heat, very small percentages of sulphur will work damage. I do not know that from personal knowledge; and am pleased to make this statement, because in England it is feared that my position regarding sulphur in gray castings may encourage the use of sulphurous ores and fuel (President Roberts' annual address, South Staffordshire Institute of Iron and Steel Works Managers, 1894). It will be noticed in Series III that the casting is high in sulphur, as compared with the pig-irons and the fuel, but it has so low a shrinkage and chill as to prevent any claim that the sulphur has exerted any evil influence. The proof seems complete that it may safely be ignored.

Carbon is the most important element in cast-iron. Without it iron could not be melted and made into castings. The percentage of total carbon determines the melting point of the iron. Carbon in melted iron is always combined, and more can be retained by the iron when fluid than when cold. On cooling, any surplus separates out into graphite, and makes a gray casting. Total carbon, no doubt, exerts an influence on strength, but such is not marked in these series.

Combined Carbon, in these series, is not by any means a controlling element, as hardly any relation can be traced between it and the physical composition. Silicon will decrease it, but in any pig-iron it is difficult to account for its presence, except on account of a lack of heat in the furnace.

Graphitic Carbon, in the series, does not correspond to any physical quality to an

SERIES I.

CHEMICAL ANALYSIS.

No. Test.	Southern Pig Iron.	Total Carbon.	Graphitic Carbon.	Combined Carbon.	Silicon.	Phosphorus.	Sulphur.	Manganese.
731	No. 2 Silvery	1 51	0.58	0.93	4.91	0.58	0.08	0 25
730	" 1 "	2.17	1.60	0.57	4.70	0 59	0.06	0.27
728	" 1 Soft	2 94	2.11	0.83	3.65	0 60	0.06	0 27
729	" 2 "	2 81	2.00	0.81	3.24	0 76	0 05	0.21
721	" 1 Foundry	2 88	2 42	0.46	2 53	0 60	0 04	0.23
724	Foundry Forge	2 29	2 28	0.01	2.16	0 62	0.19	0 19
722	No. 2 Foundry	2 16	1.90	0.26	2.00	0.79	0.08	0 23
723	" 3 "	2.14	2.04	0.10	1.83	0.77	0.10	0.31
725	Gray Forge	1 79	1 51	0.28	1.74	0.70	0.17	0.38
726	Mottled	2.74	1.00	1.74	1.36	0.76	0 36	0.31
727	White	2.01	0.67	1 34	0.94	0 76	0.42	0.29

PHYSICAL ANALYSIS.

No. Test.	Southern Pig Iron.	Dead Load.		Impact.		Shrinkage.		Chill.
		St'gh	Def.	St'gh	Def.	Square	Flat.	
731	No. 2 Silvery	295	24	305	.27	.140	.136	.01
730	" 1 "	360	.27	407	.32	.131	.138	.02
728	" 1 Soft	375	.27	407	.32	149	.157	.04
729	" 2 "	293	.25	322	.32	.130	.154	.02
721	" 1 Foundry	384	.25	407	.30	.156	.145	.01
724	Foundry Forge	362	.20	305	.21	.164	.164	.15
722	No. 2 Foundry	365	.27	373	.30	.159	.161	.01
723	" 3 "	354	.19	254	.20	.161	.148	.30
725	Gray Forge	365	.23	356	.27	.160	.163	.0
726	Mottled	372	.11	186	.14	.226	.218	white
727	White	435	.13	237	.15	.240	.....	white

SERIES II.

CHEMICAL ANALYSIS.

No. Test.	Name of Iron.	Total Carbon.	Graphitic Carbon.	Combined Carbon.	Silicon.	Phosphorus.	Sulphur.	Manganese.
715	Ensley, G. F	3.14	2 21	0.93	2.62	0.88	.....	0 16
717	Summerlee No. 1	3.38	2 92	0.46	2 00	1.27	.....	1 67
713	Tuscarawas 2 F	3 62	3 18	0.44	1 93	0.70	.....	0.88
719	Sloss, G. F	3 37	2 85	0.52	1.77	0.56	.....	0 40
720	Napier No. 3	3.65	3.56	0 15	1 76	0 85	.....	0 48
710	Eureka 3 F	3 45	2.90	0.55	1 54	0.83	.....	0.23

PHYSICAL ANALYSIS.

No. Test.	Name of Iron.	Dead Load.		Impact.		Shrinkage.		Chill.
		St'gh	Def.	St'gh	Def.	Sq're	Flat.	
715	Ensley, G. F	368	20	339	.22	.185	.186	.25
717	Summerlee No. 1	377	17	288	.18	.165	.185	.65
713	Tuscarawas 2 F	418	.24	390	.26	154	177	.30
719	Sloss, G. F	442	.22	407	26	164	.197	.....
720	Napier No. 3	423	.19	341	.21	.165	.199	.80
710	Eureka 3 F	443	.25	416	.27	.159	.163	.45

SERIES III.

CHEMICAL ANALYSIS.

No. Test.	Name of Iron.	Total Carbon.	Graphitic Carbon.	Combined Carbon.	Silicon.	Phosphorus.	Sulphur.	Manganese.
178	No. 1 Globe, Silvery	3.154	2.852	0 302	5 899	1 100	0.020	1.000
181	Alice, Silvery (Ala.)	2 963	2.742	0.221	4 853	0 597	0 010	0.199
179	No. 2 Franklin (N. Y.)	3.179	3.064	0.115	3 014	1.433	0 007	0 168
176	" 1 Poughkeepsie	3.266	3.166	0.100	2 946	1 242	tr	0 189
175	" 1 Bushong	3 343	2.879	0.464	1 932	1.089	0 013	0 136
177	" 2 Poughkeepsie	3.572	3 457	0.115	1.642	1 224	0.035	0.241
304	Casting	3.157	2 846	0.311	2 910	1.027	0.054	0 252
	Estimated in casting	3.214	2.927	0 287	3 031	1 070	0.025	0 248
Loss		0 057	0 081		0.127	0.043	.....	
Gain		.....	.....	0 024	.....	...	0.029	0.004

PHYSICAL ANALYSIS.

No. Test.	Name of Iron.	Dead Load.		Impact.		Shrinkage.		Chill.
		St'gh	Def.	St'gh	Def.	Sq're	Flat.	
178	No. 1 Globe, Silvery	297	.16	204	.....	.187	.170	.02
181	Alice, Silvery	325	.32	311	.....	.120	160	.06
179	No. 2 Franklin	328	.21	282	.....	.137	.152	.10
176	" 1 Poughkeepsie	355	.25	333	.....	.134	.147	.12
175	" 1 Bushong	374	.23	327	.....	.152	.157	.18
177	" 2 Poughkeepsie	376	.22	282	.....	148	.152	.20
304	Casting	383	.23	339	.....	.124	.149	.10

Fuel, Cross Creek Anthracite Coal, carbon, 88.94; ash, 10.18; P., 0.075; S., 0.159.

extent to attract attention. By its dividing the grains of metal, it softens carbonized iron; it also removes brittleness, and by the mechanical separation of the grain may cause weakness, but so many variations occur that the only way to be certain as to strength is by actual test. This form of carbon gives trouble in large castings, and those which must resist hydraulic pressure, by causing a spongy and open grain. It is sometimes difficult to obtain the requisite strength, closeness, lack of brittleness, softness, and low shrinkage. We do not get this knowledge from chemistry, but from practical experience. The eye, guided by common sense, will soon tell what grain is necessary to make castings fit for every purpose.

Silicon lessens the ability of iron to hold carbon in the combined state when cold; therefore, any increase of silicon will increase the graphitic carbon.

Silicon is of little use in cast-iron, except as it acts on carbon. Its influence is not direct, but through its change in the carbon. The greater the quantity of carbon present, the greater will be the influence of silicon. Silicon is the controlling element, and is the only element that the founder need take account of, except to see that the iron contains sufficient carbon for the silicon to act upon. By silicons changing combined carbon into bulky graphite, the casting occupies more room than if the carbon remained combined. This is what lessens shrinkage. The more silicon, the more graphite, and the less shrinkage.

There can be no doubt about this, after the irons of these series are examined. As silicon grows less, shrinkage increases. In very high silicon iron, so much of the carbon is completely driven out that there is not sufficient left for the silicon to act upon to reduce shrinkage, and silicon of itself increases shrinkage.

The regulation of a foundry mixture by variation of silicon, shows the influence of silicon on carbon in varying shrinkage; for all other elements remain unchanged. In this case, a variation of silicon varies chill and strength to some extent, ("Silicon in Cast-iron," A. I. M. E., vol. xvii, p. 863, 1889). Different kinds of castings require different percentages of silicon, which can be learned by the founder by a study of the shrinkage of a ½-inch test bar. The figures representing the percentage are of little account. What he wants to know is whether the casting contains the right amount.

Silicon is more effectual as found in some irons than in others. To illustrate this, we introduce Series V.

F L M is a Swedish charcoal pig which I use in trying other irons. It is very sensitive to any outside influence. Ashland is a very close-grained silvery iron. The No. 3 silvery (794) contained nearly the same silicon and had a similar close grain. For 793 and 792 enough of each of these silvery irons were added to F L M to make the silicon of the mixture 2.50 per cent. If only an analysis of silicon and combined carbon had been made it would be conceded that 794 was better than 525. It has high sulphur, but this does not seem to increase combined carbon. The phosphorus was about 0.80 per cent., while that of 525 was high. As a reducer of shrinkage 525 is perfect, but 794 increases shrinkage. As a reducer of chill 794 is better than 525. The inability of 794 to reduce shrinkage lay in its own lack of graphite. Total carbon in 792 is reduced so much that its shrinkage is greatly increased.

This proves positively that a silicon analysis, or silicon and combined carbon analysis, is not as safe a guide in the purchase of an iron as the shrinkage test, that is, a mechanical analysis.

Fracture and Silicon.—The irons of Series I were selected by the face of the pig more than by fracture, and this is the furnace method of grading. These pigs were drilled and shipped to me at once before any determinations were made, but the analyses show that the surface grading was correct, and the fracture is such as to leave no question as to grade, and it also shows that the silicon is indicated by the fracture, except in the single case of foundry forge. It is a little remarkable that about the only thing that the chemical analysis of these pigs does show, is that the appearance of the pig indicates quality so far as silicon and carbon are concerned.

It is a fact beyond a question that of two irons having the same chemical composition, the one having the most open grain will make the best castings, because it was made at a higher temperature.

The Purchase of Pig-iron by Analysis would lead to more dissatisfaction than by fracture, because the openness of the grain is very important.

SERIES IV.
CHEMICAL ANALYSIS.

No. Test.	Treatment.	All Tests from Same Mixture.	Total Carbon.	Graphitic Carbon.	Combined Carbon.	Silicon.	Phosphorus.	Sulphur.	Manganese.
788	Temp.	First of Heat..	2.910	2.280	0.630	3.220	1.025	0.123	0.490
791	Test.	Last of Heat....	2.950	2.470	0.480	3.140	1.055	0.100	0.470
780	Iron	1st Set	.....	.....	.....	3.520	.....	0.081	.....
782	Stirred.	3d Set One Ladle.	.....	.....	.....	3.520	.....	0.080	.....
784	Allowed	1st Set	.....	.....	.....	3.460	.....	0.079	.....
787	to Stand.	4th Set One Ladle.	.....	.....	.....	3.450	.....	0.083	.....

PHYSICAL ANALYSIS.

No. Test.	Treatment.	All Tests from Same Mixture.	Dead Load. Strength.	Dead Load. Def.	Shrinkage. Square.	Shrinkage. Flat.	Chill.
788	Temp.	First of Heat.....	390	.22	.163	.182	.15
791	Test.	Last of Heat	400	.22	.121	.140	.07
780	Iron	1st Set	440	.23	.123	.139	.05
782	Stirred.	3d Set One Ladle.	530	.27	.131	.....	.02
784	Allowed	1st Set	400	.23	.128	.143	.02
787	to Stand	4th Set One Ladle.	500	.25	.128	.136	.02

SERIES V.
CHEMICAL ANALYSIS.

No. Test.	Name of Iron.	Total Carbon.	Graphite.	Combined Carbon.	Silicon.	Phosphorus.	Sulphur.	Manganese.
441	F L M	3.550	3.220	0.33	1.249	0.080	0.040	0.190
525	No. 3 Ashland Silvery.....	3.333	3.124	0.209	4 700	1 543	0.044	0.963
794	No. 3 —— Silvery.	1.210	1.160	0.05	4 410	.....	0 114	.....
793	441 and 525.....	Car. not mat. lowd			2.50	Inc.	Same	.....
792	441 " 794	" is " "			2.50	same	Inc.	.....

PHYSICAL ANALYSIS.

No. Test.	Name of Iron.	Dead Load. St'gh	Dead Load. Def.	Impact. St'gh	Impact. Def.	Shrinkage Sq're	Shrinkage Flat.	Chill.
441	F L M.....	362	.27	339	.29	.168	.186	.40
525	No. 3 Ashland Silvery.....	352	.15	145	.14	.156	.155	.50
794	No. 3 —— Silvery	260	.17	.....	.....	.184	.183	.01
793	441 and 525.....	378	.22	246	.19	.143	.156	.23
792	441 " 794	407	.25	399	.27	.190	.185	.15

SERIES VI.

No. Test.		Dead Load Strength.	Gain.	No. Test.		Dead Load Strength.	Gain.	Impact Strength.	Gain.
653	Horizontal.....	373		672	Horizontal.....	383	.....	435	.....
655	On End.....	512	139	673	On End	438	55	526	91

SERIES VII.
PHYSICAL ANALYSIS.

No. Test.	28 lbs. Iron in one Ladle. (Rested).	Dead Load. St'gh	Dead Load. Def.	Impact. St'gh	Impact. Def.	Shrinkage. Sq're	Shrinkage. Flat.	Chill.
784	Poured on reaching floor.	388	23	348	.24	.128	143	.02
785	" 1 minute later	393	.21	331	.23	.128	139	.02
786	" 1 " "	424	.21	406	.25	.128	.135	.02
787	" ½ " "	466	.24	347	.24	.128	.135	.02

SERIES VIII.
PHYSICAL ANALYSIS.

No. Test.	28 lbs. of Iron. (Stirred).	Dead Load. St'gh	Dead Load. Def.	Impact. St'gh	Impact. Def.	Shrinkage. Sq're	Shrinkage. Flat.	Chill.
776	Poured on reaching floor.....	403	.21	296	.22	.127	.140	.02
777	" ¾ minute later.....	463	.25	313	.....	126	.137	.02
778	" ¾ " "	481	.26	423	.24	127	.135	.02
779	" ½ " "	483	.26	304	.20	127	.....	.01
780	Poured on reaching floor.....	418	.22	399	.24	.123	.139	.05
781	" ¾ minute later.....	488	.27	458	.25	.128	.139	.04
782	" ¾ " "	508	.27	491	.26	.131	.....	.02
783	" ½ " "	.....	.....	.....	.....	.128	.....	.02

SERIES IX.
PHYSICAL ANALYSIS.

No. Test.	Difference in Cupola Temperature.	Dead Load. St'gh	Dead Load. Def.	Impact. St'gh	Impact. Def.	Shrinkage. Sq're	Shrinkage. Flat.	Chill.
788	First iron from cupola.....	373	.21	293	.20	.162	.182	.15
789	1 hour later	369	.21	280	.21	.137	.147	.04
790	1 " "	367	.21	297	.22	.130	.141	.05
791	Last iron..	398	.22	308	.25	.121	.140	.07
795	First iron	431	.22	373	.24	.158	.165	.08
796	1 hour later.....	429	.23	432	.27	.132	.144	.03
797	1 " "	448	.23	424	.26	.136	.140	.03
798	Last iron.....	396	.23	297	.22	.132	.144	.06
799	First iron.....	415	.23	373	.24	.159	.165	.07
800	1 hour later.....	453	.23	382	.24	.136	.148	.03
801	1 " "	455	.25	398	.26	.130	.141	.05
802	Last iron..	477	.27	415	.25	.125	.140	.06

It would amount to a guarantee on the part of the furnace, and 50 cents per ton would be a small advance to cover expense and risk.

If a second analysis was made it would not agree with the first. It is never claimed that anything but silicon would be guaranteed, but total carbon is of as much importance as silicon.

If the founder knows enough about iron to know the approximate silicon by the fracture, he will be able to buy silicon cheaper by fracture, and if the iron happens to be deficient in silicon it is easily made up. For example, Alice of Series III was bought and delivered as No. 2 foundry, but proved to be the best silvery iron that could be bought. Even if silicon is the same in an open and in close-grained iron, the close-grained iron is most likely to be deficient in carbon, or to have been made at a low heat.

Physical Quality Independent of Chemical Constitution.—This is true to a great extent, as the following will prove: In Series VI from the same ladle of iron were poured two sets of test bars, one set (653) cast horizontal and the other (655) cast on end, being fed from the bottom. The test was repeated in 672 and 673.

No one would claim any difference in chemical constitution. In Series VII, I give four average tests to show the influence of time and cooling after iron is caught in a ladle. Time allows particles of slag and gas to escape, and cooling causes a more compact grain.

The two sets of tests in Series VIII are exactly alike, but made some days apart. The ladle held 28 pounds of iron and on reaching the molder's floor a steel bar, with the end about one inch in diameter, was introduced two inches below the surface, and with it the surface was stirred slowly for one half minute. It took one-quarter minute to pour the three flasks of test bars. The surface was then stirred as before and so on. The metal was so cold that before the fourth pouring the surface was stirred very little. The metal was cooled more than in Series VII, and the agitation, no doubt, helped to remove slag and gas.

In Series IV, I gave analysis by Cary and Moore of one bar of the following tests: (784) Si. 3.46, S. 0.079; (787) Si. 3.45, S. 0.083; of test (780) Si. 3.52, S. 0.081; (782) Si. 3.52, S. 0.080. The analysis of the series 776–779 would have been substantially the same because the iron mixture was not changed. There is practically no variation in shrinkage and chill, and no variation in chemical composition, and yet there is a very great change in strength, which is due to two causes, the clearing of the metal from slag and gas on account of time, and the lessening of internal stress, because the first bars poured formed a rigid shell around very hot metal. In cooling and crystallizing, each grain tended to pull away from those next to it. The bars of the last cast being colder, made a more solid casting with less internal stress. It is always customary to allow metal to become as cold as possible before pouring, so as to get the greatest strength.

Getting metal which has been melted hot in a cupola, into a mold as cold as possible, must not be confounded with melting cold in a cupola. Of this latter I give three examples in Series IX.

The cold cupola, at the beginning of a heat, gives high shrinkage every time, and the shrinkage comes down as soon as the cupola is hot. A complete analysis of tests 788 and 791 was given in Series IV. The iron in this first experiment was poured as soon as the molder reached his floor. The cupola mixture of the last two was the same as in the first, but the molder used the first part of his iron for other work, and poured the test bars with the last iron in his ladle. The iron went into the molds of the first hot and into the last two cold, and after some agitation in pouring the other work. In this way this series show the effect on strength, of manipulation, not in the least dependent on chemical constitution. These series show the exceeding sensitiveness of of "Keep's Test," and what information it can give the founder.

Suggestions for using "Keep's Test" in the purchase of pig-iron, and in controlling a foundry mixture. Remember that we ig-

nore phosphorus sulphur and manganese in our casting, but in purchasing iron always give preference to iron having the least (and always buy the purest coke possible, because it gives most heat). Carbon must be taken as we find it. The more there is, the less silicon will be required to produce a desired result, and *vice versa*. Silicon can do nothing except through carbon, and carbon may be so low that silicon cannot reduce shrinkage. You must know from such tables as Series I, II and III the average silicon in the grades of iron which you use. Use as many varieties as you can, counting each number and name a variety. This is to lessen the chances for change in quality of casting, on account of change in some iron. To make your first mixture, if your casting ought to contain 2.25 per cent. of silicon (err by having it too high rather than too low), make a mixture for the cupola charge which will give approximately 2½ per cent. Run off a heat, and make one flask containing a square and a flat test bar, cast in yokes to get shrinkage and chill, and two flasks containing only square bars. Arrange to catch the iron at one time each day, and treat it always in exactly the same way. Perhaps the best way for ordinary practice is to pour it at once after it is skimmed. If the castings are satisfactory, the record of these test bars will be standard, if not increase or decrease silicon by varying the proportion of irons, until the castings are satisfactory, and then keep as close to this record as possible. You now know what you are making, and make a rule never to vary a mixture by more than one or two irons, and not more than 100 pounds of each at one time. If you wish, on account of price, to change one or more of your irons, order a car load and put 100 pounds on each charge, instead of the iron you wish to abandon. If shrinkage rises, the silicon in the new is not as efficient as in the old iron, and if you use it you will have to get the silicon necessary to restore shrinkage from some other iron. If shrinkage goes down the silicon of the new iron is more efficient than the old, and you can increase your scrap, or other low silicon iron.

In the purchase of coke, if you wish to tell which is best, have the sulphur in your casting determined before you make any change. Then without making any change in iron mixture, substitute another coke, and get sulphur determination of casting. After a few trials you can tell which coke imparts most sulphur in your iron, and this analysis is better for you, than any determination of sulphur in coke which is rarely satisfactory. Or, you can simply rely on your test bar record, which will tell you which coke makes the best casting without any worry about why.

This is really using chemistry in the foundry, but in a simple, practical way, dealing only with results.

MANUFACTURES.

There is talk of the erection of a cotton-oil mill at Yorkville, S. C.

A new electric-light system is being established at Flatbush, L. I.

An electric-lighting plant will probably be established at Benton, Ark.

There is talk of the erection of a cotton-mill plant at Demopolis, Ala.

C. T. Aheles & Co. will erect a $5,000 factory building at Little Rock, Ark.

An electric-railway system is talked of to connect Washington, D. C., and Manassas.

J. P. Moore is interested in a project to erect a cotton-mill plant at Carrollton, Ga.

M. R. Russell is interested in a cotton-seed oil-mill to be erected at Carrollton, Ga.

The Cunnannison Electric Light Company has been incorporated at Palmyra, N. Y.

W. H. Mahley is interested in a project to establish a cotton-oil-mill at Cochran, Ga.

An electric-railway system will probably be established between Fredericksburg and Culpeper, Va.

J. Allen Smith has organized a company to erect a door, sash and blind factory at Abbeville, S. C.

The capital of the Ticonderoga (New York) Machine Co. has been increased from $125,000 to $200,000.

The insurance on W. Tinkham's burned mill at Harrisville, R. I., has been adjusted, and work will commence on a new and large four-story mill.

The Hendey Machine Co., Torrington, Conn., inform us that they have been running full time since February 1st, employing 125 to 130 men, as compared with their usual force of 175 men. They say business is improving with them.

J. A. Fay & Co., Cincinnati, O., inform us that they are receiving much help in the sale of their sandpapering machines from varnish manufacturers, who recognize the fact that the fine surface left by these machines gives their varnish a much better opportunity to show its immediate effect and to demonstrate its lasting qualities.

Curtis & Curtis, Bridgeport, Conn., are having difficulty in filling orders, especially for the Forbes pipe machines. They recently received an order, by cable, from England, for 24 of these machines, all one size, and the following day the same firm cabled an additional order. Curtis & Curtis, from all we can learn, are not doing much grumbling about dull times.

A Washington dispatch says: The erection near this place of probably the most extensive tin plate plant in the United States is practically assured. The company is composed of New York capitalists. The capital stock of the company is $300,000. The works will cover several acres of ground and give employment to 600 men. It is intended to have the works in operation by December next.

E. G. Smith, Columbia, Pa., writes us: The Franklin Educational Company, of Boston, Mass., have taken up the agency and sale of my metric instruments. They will introduce them into manual training schools and other educational institutions. They are now in use in quite a number of them, and are giving the best of satisfaction, as the teachers and pupils are appreciating the vernier as applied to these tools.

The Frick Company, Waynesboro, Pa., inform us that they are now working about 60 per cent. of their accustomed force, same being a considerably larger number than were employed during the fall and winter. They are putting on more men right along, and a recent visit to their works shows a fairly reassuring degree of activity, especially in their refrigerating machinery department, with favorable inquiries and prospects as to their "Eclipse" Corliss engines. Taken as a whole, by comparison with the recent past, their present report as to the condition of

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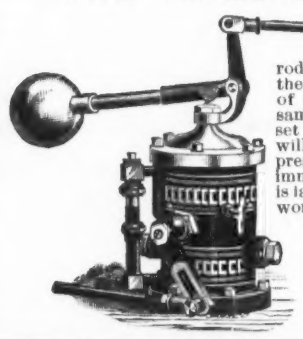

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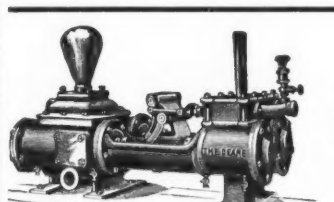

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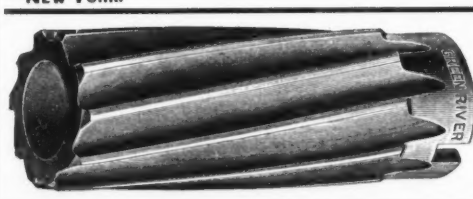

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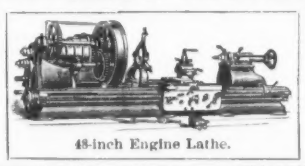

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their business is quite favorable, except that prices are unsatisfactorily low

The Buckeye Engine Company issue the following: We beg to inform you that, on April 1st, we will remove our office from 18 Cortlandt street to 39 and 41 Cortlandt street. We will have larger and more commodious offices, where we will be pleased to see our patrons and friends at all times, and give any information or estimates they may desire. In addition to our regular line of plain, tandem compound, cross compound, and triple-expansion horizontal engines, we wish to call your attention to our new vertical compound engines for electric light and railway service, ranging from 150 horse power to 1,200 horse-power and over. This engine is specially adapted for direct connecting to dynamos, and we guarantee it to work as economically as any compound engine on the market, and to run with superior regulation.

The organization of the Fairfield Copper Co., of which Edward L. Smith, of Ansonia, is treasurer and general manager, was completed recently. The certificate accepting the articles of incorporation was filed in the office of the Secretary of State of New Jersey, under the laws of which it was organized. This company is to build the smelting plant at Monroe, as has been previously stated in *The Sentinel*. The machinery for this plant has been ordered, all of the plans are drawn, contracts have been placed, and work will be begun upon the foundations this week. It is expected to complete the building operations during June, and work will be immediately begun. This will have an effect upon Ansonia in this way: The Fairfield Copper Company will purchase and put through the smelting process at this new plant large quantities of copper. This will in turn be brought to the Electrolytic Copper Refining Company, of this place, and subjected to its refining process. Edward L. Smith told a *Sentinel* reporter recently that the Ansonia concern would be rushed with business early in the summer.—*Ansonia* (Conn.) *Sentinel*.

E. W. Bliss Company, Brooklyn, N. Y., write us: While many believe that an early return to the normal conditions of business is improbable, yet there are concerns who find much encouragement in the outlook for the near future. We are erecting in our works two of the largest and heaviest presses we make, viz., our No. 14 and 15 toggle drawing presses. The No. 15 press weighs about 140,000 pounds, and is driven by an engine attached to it. It is about 14½ feet in height, and has a width between the uprights of 54 inches, and will draw articles up to 11 inches in depth. It can be started or stopped at any point in the stroke by means of a friction clutch. These presses are used in drawing up such articles as kitchen boiler heads, cylinders, steel sinks, heavy black iron, and enameled ware. The No. 15 press we expect to ship in about a week to England, to be used in drawing up heavy steel shells. The No. 14 press is somewhat lighter, weighing about 75,000 pounds, having a distance between the uprights of 30 inches, and will draw articles in depth up to 10½ and 12½ inches. This press while it will draw articles of greater depth, has not the requirements for doing nearly as heavy work as the No. 15 press. This press is being built for one of our large tin ware stamping concerns in this country for drawing up heavy enameled iron ware of various descriptions. We also have a large number of smaller machines in process of erection in our works. Enquiries for new tools from manufacturers who are increasing their capacity have been very frequent lately, and give us assurance of better times not very far ahead.

The Buckeye Engine Company, Salem, Ohio, write us: We name below the sales recently made by us. Although this list is considerably smaller than last year we feel that we have a good share of the engine trade: J. T. Williams, New York City, 150 horse-power, slow speed. Cleveland Milling Co., Cleveland, O., 125 horse-power, slow speed. Alfred Ricker, Hartford, Conn., 125 horse-power, slow speed. D. J. Murray Mfg. Co., Wausau, Wis., 70 horse-power, medium speed. Bloomfield-Pearson School, Tufts College, Mass., 25 horse-power, high speed. Minnesota State Public School, Owatonna, Minn., 50 horse-power, high speed. Ellsworth Electric Illuminating Company, Ellsworth, Me., 180 horse-power, high speed. Coplay Cement Company, Coplay, Pa., 600 horse-power, slow speed cross compound. Dayton St. Railway Company, Dayton, O., three 500 horse-power, tandem compounds, medium speed, arranged for direct connection to Siemens & Halske generators. King Powder Company, Kings Mills, O., 500 horse power, medium speed, tandem compound. Diamond Match Company, Barberton, O., two 125 horse-power and one 90 horse-power tandems. C. & O. Southwestern R. R. Co., Paducah, Ky., 150 horse-power, medium speed. Blish Milling Company, Seymour, Ind., 600 horse-power, medium speed cross compound. McKeesport & Wilmerding St. Railway Co., McKeesport, Pa., 80 horse-power, medium speed. The Snell Cycle Company, Toledo, O., 125 horse-power, medium speed. Edward McDonald, McDonald, Pa., 90 horse-power, high speed. Bakhaus & Kuenzels, New Bremen, O., 100 horse-power, slow speed. J. T. Williams, New York City, 70 horse-power, slow speed. Garland Chain Company, Rankin, Pa., 100 horse-power, slow speed, cross compound. American Rubber Company, E. Cambridge, Mass., 60 horse-power, high speed. Richmond Light, Heat and Power Company, Richmond, Ind., two 300 horse-power, medium speed, tandem compounds.

Machinists' Supplies and Iron.

New York, April 7, 1894.

Iron—American Pig—We quote Standard Northern brands, No. 1 Foundry, $12.75 to $13.50; No. 2, $12.00 to $12.50; Gray Forge, $11.25 to $12.00. Southern brands of good quality are obtainable at $12 25 to $13.00 for No. 1 Foundry; $11.00 to $11.50 for No. 2, and $10.75 to $11.25 for Gray Forge.

Antimony—The market is dull and quiet. We quote L. X., 9¼c. to 9⅝c.; Cookson's, 10c. to 10½c.; Hallett's, 8.65c. to 8.75c., and U. S. French Star, 10c.

Lard Oil—Prime is quoted at 62c. to 62½c.

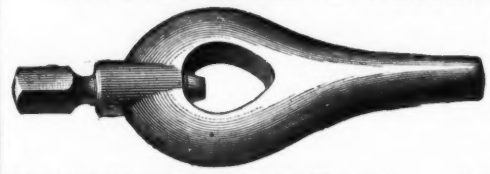
Copper—The market is extremely quiet, and business seems to be at a standstill. Lake Copper is quoted at 9.45c. to 9.50c. Casting Copper is held at 9.10c. to 9¼c.

Lead—The market is weak, the demand is trifling, as buyers are waiting for a more settled state of affairs. Commercial brands can be bought at 3.37½c. for New York delivery. The official bullion quotation is 3.20c.

Spelter—The market is weak, and values are nominal at 3.75c. to 3.80c. for New York delivery. There is no demand.

Tin—The market is unsettled, and without any speculative interest of importance. Buyers of small lots are being accommodated at 19.35c. for prompt delivery.

REDUCED PRICES OF LECOUNT'S STRAIGHT TAIL DOG.



To be driven from a Stud in the Face Plate.

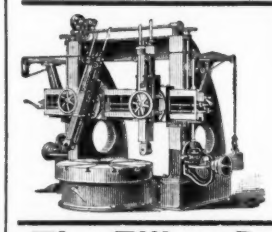
No.	INCH.	PRICE.	No.	INCH.	PRICE.
1	¾	$0.60	10	2¼	$1.35
2	⅞	.70	11	2½	1.45
3	1	.70	12	3	1.60
4	1⅛	.80	13	3½	1.80
5	1¼	.80	14	4	2.10
6	1⅜	.95	15	4½	2.75
7	1½	.95	16	5	3.25
8	1¾	1.10	17	5½	4.00
9	2	1.20	18	6	5.00
1 Set to 2 in.		7.80	Full Set.		31.10

These Goods are for sale by CHAS. CHURCHILL & CO., L't'd, 21 Cross St., London, England.

C. W. LeCOUNT, South Norwalk, Conn.

DON'T ACCEPT ANY SUBSTITUTE FILE.
INSIST ON HAVING NICHOLSON.

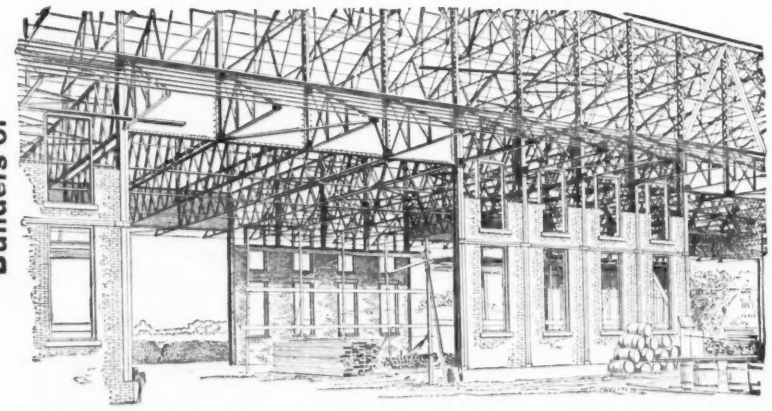
NICHOLSON FILE CO.
PROVIDENCE, R. I., U. S. A.
3000 VARIETIES FILES
[X. F.] & INCREMENT CUT FILES.



BORING AND TURNING MILLS
COMBINING EVERY IMPROVEMENT.
14 SIZES FROM 5 TO 20 FEET.
BETTS MACHINE COMPANY,
WILMINGTON, DEL.

THE BERLIN IRON BRIDGE CO.
Office and Works,
No. 8 Railroad Ave., East Berlin, Conn.
CHAS. M. JARVIS, Pres. and Chief Engineer. BURR K. FIELD, Vice-President.
FRANK L. WILCOX, Treasurer. GEO. H. SAGE, Secretary

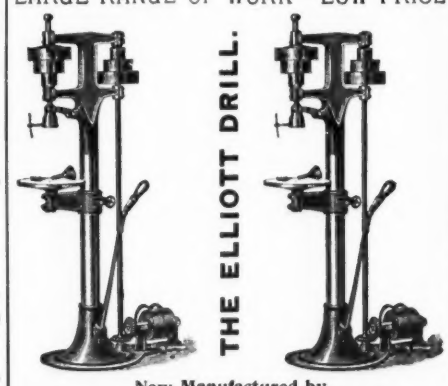
Engineers, Architects and Builders of Iron and Steel Bridges and Buildings.



The above illustration is taken direct from a photograph, made during the construction, and shows the details of an Iron Building designed and built by us for the Newport News Ship Building and Dry Dock Co., at Newport News, Va. The building is 60 feet in width by 320 feet in length, and is two stories high—the lower floor being used as a Ship Shed for punching, bending, riveting, etc.—the upper floor being used as a Mold Loft. Outside of the building, extending entirely around it on all four sides, is an overhang 12 feet wide, thus affording additional shop room outside of the building, where raw material may be stored and still be protected from the weather. Wide openings are placed every 40 feet so that raw material may be taken in, and finished product moved out, cheaply and quickly. The supporting frame is all iron throughout, and between the iron posts on the sides is a light brick wall.

SEND FOR OUR ILLUSTRATED CATALOGUE.

The Elliott Drill Press
FOR ANY LIGHT WORK
LARGE RANGE OF WORK - LOW PRICE



THE ELLIOTT DRILL.

Now Manufactured by
A. J. WILKINSON & CO.,
180 to 188 WASHINGTON ST., BOSTON, MASS.
SEND FOR CATALOGUE.

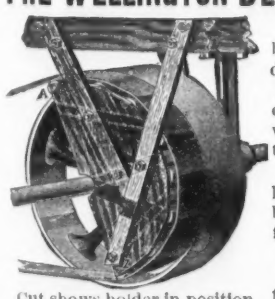
Pat. KEY-SEAT SETTING GAUGE
PATENT UNIVERSAL SCREW-CUTTING CENTER DEPTH ANGLE AND **TWIST DRILL GAUGE**
J. WYKE & CO. Fine Machinists' Tools. E. BOSTON, MASS. Send for LISTS

JESSOP'S STEEL
FOR TOOLS, DRILLS, DIES, &c.
ALL KINDS IN STOCK.
Manufactory, SHEFFIELD, ENG.
Chief Am. Office, 91 JOHN ST., N. Y.
WM. JESSOP & SONS, LTD.
Established a century ago.
Medal World's Columbian Exposition 1893.

"Star" Foot Lathe Swings 9x25 in.
LATHE
Screw Cutting Automatic Cross Feed, etc.
$85
LATHE
Scroll Saws, Circular Saws, Lathes Mortisers.
Catalogue Free of all our Machinery.
Seneca Falls Mfg. Co. 687 Water St., Seneca Falls, N.Y.

BUILDERS IRON FOUNDRY,
FOUNDERS AND MACHINISTS.
PROVIDENCE, R. I.
Globe Special Castings for Water Works, Mills and Railroads.
These castings were designed by a practical Water Works man. They are strong, compact, convenient, easy to handle and cheap to transport. They are sold by the piece and the total cost of the contemplated expenditure may be known in advance. All common sizes carried in stock. Price list mailed upon application.

THE WELLINGTON BELT HOLDER.



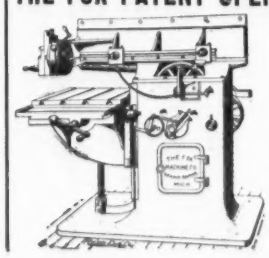
Cut shows holder in position beside driving pulley.

Large or small belts shifted from driving pulley and held at rest, and easily slipped back when machine is to be started.
It dispenses with loose pulleys, saves belts, and is perfectly safe.
It is *cheap*.
Write for descriptive circular and price list to

COOKE & CO.,
163 & 165 WASHINGTON STREET, NEW YORK,
And mention American Machinist.

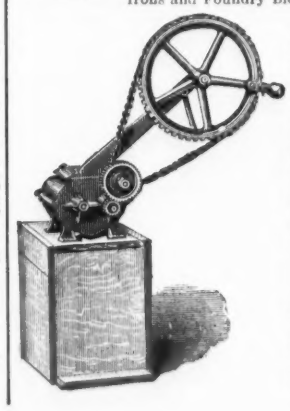
HENRY CAREY BAIRD & CO.,
INDUSTRIAL PUBLISHERS, BOOKSELLERS AND IMPORTERS,
810 Walnut St., Philadelphia.
☞ Our New and Revised Catalogue of Practical and Scientific Books, 88 pages 8vo., and our other Catalogues and Circulars, the whole covering every branch of Science applied to the Arts, sent free and free of postage to any one in any part of the world who will furnish his address.

THE FOX PATENT OPEN SIDE SHAPER.



No springing of ram. No overhanging table. Quick Return, Stroke Under Perfect Control. Can be Instantly Adjusted 1-16 in. or 24 in. No Screws to Monkey with. Powerful, Quick, Accurate. Write for circular.
The Fox Machine Co.,
325 N. Front St.,
Grand Rapids, Mich.
135 Finsbury Pavement, London, England.

ROOTS' NEW ACME HAND BLOWER.
For Blacksmiths, etc. Slow Speed, Positive Blast. Is Durable, Compact and Cheap; also Portable Forges, Tuyere Irons and Foundry Blowers.



P. H. & F. M. ROOTS, Mfrs.
CONNERSVILLE, IND.
Chicago Office: 501 MANHATTAN BUILDING.
S. S. TOWNSEND, Gen. Agt. } 163 & 165 Washington St., NEW YORK.
COOKE & CO., Selling Agts. }
Please Mention This Paper.

WORTHINGTON PUMPING ENGINE
FOR
WATER WORKS.
SIMPLE, COMPOUND, OR TRIPLE EXPANSION, HORIZONTAL OR VERTICAL
HIGHEST DUTY GUARANTEED.
COMPLETE DESCRIPTIVE PAMPHLETS ON APPLICATION.
HENRY R. WORTHINGTON,
NEW YORK,
BOSTON, PHILADELPHIA, CHICAGO, ST. LOUIS, DENVER.

✲WANTED✲

"Situation and Help" Advertisements only inserted under this head. Rate 30 cents a line for each insertion. About seven words make a line. Copy should be sent to reach us not later than Saturday morning for the ensuing week's issue. Answers addressed to our care will be forwarded.

1st-class molder desires sit., dry or green sand, temperate. N. E or N. Y. pref'd. Box 39, A. M.

Position wanted by mech. eng. of 7 years exp. as mach. and draftsman. O., Am. Machinist.

Wanted—Position as draftsman tech. grad., 3 yrs. exp., American. Box 53, Am Machinist.

Tool maker wants sit., capable of getting up gigs & other fixtures, best refs. W. S., Am Mach.

Wanted—Sit. as foreman mach., 25 yrs building stat'y & marine engs., highest refs. Box 54, A. M.

A prac. mech., 8 yrs. foreman, wants pos.; age 34, habits A 1. Foreman, American Machinist.

Wanted—Sit. as foreman of mach. shop; accurate, heavy work preferred; age 33, A1 references. Practical, American Machinist.

Mech. draftsman desires sit., 7 yrs. exp., mach. tools and general machinery, jigs, etc.; shop experience, prac., good designer. Box 56, Am. Mach.

Wanted—By a practical machinist, a situation to work at trade and learn to run a stationary engine. Address Box 57, American Machinist.

Wanted—By first class eastern boiler maker, position as supt. or foreman, handle men to best advantage, 15 years exp. Box 59, Am. Machinist.

Loam molder wants position, well up in marine, land engine, sugar house, and general jobbing work, able to take charge. Box 60, Am. Mach.

Wanted—Position as foreman in iron foundry, one familiar with all kinds of light and heavy castings in green, dry sand, and loam; references from last employer. P. H. Fox, Am. Machinist.

Mechanical engineer of large experience wishes position as superintendent, head draftsman or to travel for manufacturing concern, A1 reference. Box 55, American Machinist.

Wanted—Situation by experienced mechanic with theoretic education, designer of special tools and well acquainted with interchangeable system; held positions as foreman, head draftsman and assistant superintendent. A. B., Amer. Machinist.

Situation wanted by energetic, pushing and inventive mech. eng., thorough mechanic, able to make estimates, draft mach'y and take general supervision of work. Large exp. in hydraulic, pneumatic, marine and haulage engs., cable roads, structural iron & timber work, etc. Box 58, A. M.

Young engineer, 9 yrs. general mach. shop and drawing office exp., with requisite tech. knowledge appertaining to machine design, desires position at designing with a firm making high-grade engines, pumps, automatic machines or machine tools; where he could gain a comprehensive knowledge of some special class of work. Address Box 61, American Machinist.

✢ MISCELLANEOUS WANTS ✢

Advertisements will be inserted under this head at 35 cents per line, each insertion. Copy should be sent to reach us not later than Saturday morning for the ensuing week's issue. Answers addressed to our care will be forwarded.

Cheap 2d hd lathes & planers. S.M.York,Clev'd,O.

Auto. Steam Flue Cleaners. Kelley Co., Erie, Pa.

For Sale—Second-hand drill presses,engine lathes & planers. Dietz, Schumacher & Co., Cincinnati, O.

Light and fine machinery to order; Foot Lathe Catalogue for stamp. E. O. Chase, Newark, N. J.

Calipers, Surface Gauges, etc. Catalogue free. Send for it. F A. Welles, Milwaukee, Wis.

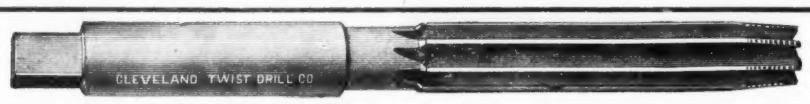
Wanted—2d-hand 4 or 6 block wire-drawing bench, and two No. 4 Perkins' wire nail mach. in good condition. J. J. Gordon, Carleton, St. John, N. B.

Machinists to buy at bargain prices to close out Brown & Sharpe's, Starrett's, Stevens & Stubs' tools, Stubs', Grobet and American files. Frasse Co., 19 Warren street, N. Y.

Introduction and negotiation of American patents and machinery to English manufacturers and agents. Write for circular to Geo. Richards, M. I. M. E., Mechanical and Consulting Engineer, No. 5 Laurence Pountney Hill, London, England.

Michigan Agricultural College offers instruction in mechanical engineering—four years' course; the average expense of attendance at the college is $135 per year; the course is arranged so as to give students an opportunity to earn a portion of their expenses. Address Mechanical Department, Agricultural College P. O., Mich.

For Sale—38 in. x 16-ft Lodge-Davis Engine Lathe; 36 in. full Automatic Brainerd Gear Cutter; 25 in. full Automatic Gould & Eberhardt Gear Cutter. These tools have been used less than one year, and are as good as new. Address The Fosdick & Plucker Machine Tool Co., 142 Culvert street, Cincinnati, O.

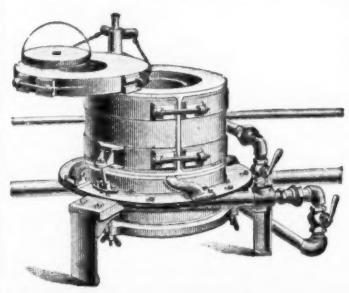


Established in 1874.

CLEVELAND TWIST DRILL CO.

COR. LAKE & KIRTLAND STS. CLEVELAND, O.

100 & 102 Reade Street, New York.
85 Queen Victoria St., London, Eng.
5 Neue Promenade, Berlin, C., Germany.



AMERICAN GAS FURNACE CO.,

OIL GAS PLANTS

Gas Blast Furnaces & High Pressure Blowers

For the economical generation and systematic application of HEAT.

CATALOGUES ON APPLICATION.

No. 80 Nassau Street, - - NEW YORK.

English Agency:
Chas. Churchill & Co., Ltd., 21 Cross Street, Finsbury, London, E. C., England.

GRAHAM TWIST DRILL AND CHUCK CO., DETROIT, MICH., U. S. A.

SOLE MANUFACTURERS OF

GRAHAM'S GROOVED SHANK TWIST DRILLS AND CHUCKS.

Endorsed by Practical Mechanics Everywhere. Send for Catalogue.

Second-Hand Machinery

MODERN STYLE, IN GOOD ORDER
BEING THE EQUIPMENT OF A
MACHINE TOOL SHOP
AND AN
ENGINE AND BOILER WORKS.

IRON PLANERS, 16 in. x 4 ft., 19 in. x 3 ft., 20 in. x 4 ft.
22 in. x 6 ft., 24 in. x 4, 5 and 6 ft.
26 in. x 6 and 8 ft., 30 in. x 6 and 10 ft.
32 in. x 6 ft., 36 in. x 8, 10 and 16 ft.
ENGINE LATHES, 13 in. x 6 ft. 16 in. x 6 and 8 ft., 18 in. x 8 ft.
20 in x 10 and 12 ft., 24 in. x 10, 12 and 16 ft., 30 in. x 10 ft., 32 in. x 16 ft., 52 in. x 24 ft., 84 in. x 18 ft.
PIT LATHE, to turn up to 16 ft. wheels.
SHAPERS, 6, 8, 9, 12, 15, and 16 in.
UPRIGHT DRILLS, 20, 24, 48 and 68 in.
RADIAL DRILLS, 3 and 4 ft. arms.
MILLING MACHINES, "Cini" No. 2, also "Ingersoll," extra heavy Table 22 in. x 4 ft.
GEAR CUTTER, cuts 36 in. Spur and Bevels, "Gould's."
KEYSEATING MACHINE for Pulleys and Wheels.
UPRIGHT BORING AND TURNING MILL, 38 in. with two heads.
UPRIGHT TURRET CHUCKING MILL, Brown & Sharpe's.
STEAM HAMMER, 300 lbs., "Ferris and Miles."
BOILER BENDING ROLLS, 6, 8 and 10 feet.
BOILER PUNCH AND SHEAR, 36 in. gap; 1 in. through, 1 in. iron, weight 14,000 lbs. "Improved style."
BOILER FLANGE CLAMPS, 6 and 10 ft.
BRIDGE RIVETING MACHINE, "Allen's Pneumatic."

J. J. McCABE,

SUCCESSOR TO
E. P. BULLARD'S
N. Y. Mach'y Warerooms.

14 Dey St.,
NEW YORK.

MACHINERY

NEW AND SECOND-HAND.

Plate Planer, 16½ ft., one setting. 1 in. Plate.
Shear No. 27, 30 in. throat, ¾ in. plate.
Above entirely New, made by Bement, Miles & Co.
Boiler Rolls, 8 ft. 3 in. between Housing. Cheap.
Punch, 21 in. throat. Teal.
57 in. Swing Driving Wheel Lathe, Double Head.

ENGINE LATHES.

100 inches x 20 feet.
74 " 24 "
51 " 18 "
48 " 16 "
40 " 14 "
25 " 24 and 16 feet.
24 " 25 feet.
Other Sizes.

Profiling Machine, P. & W.
No. 1 & 3 Universal Miller, B. & S.
1,500 Steam Hammer, Morgan.
200 Bradley " Upright.
Lot of Polishing Machines.
Shafting, Belting.

PLANERS.

72 inches x 25 feet. 4 Heads.
69 " 15 " 1 "
60 " 20 " 2 "
42 " 12 " 1 "
36 " 16 " 2 "
30 inches x 12 feet. 1 Head.
30 " 8 " 1 "
Smaller Sizes Planers.
9, 12, 14, 24 and 26 in. Shaper.
8, 12, 18 in. Slotter.
Drills, Radial and Post.
Screw Machines No. 1, 2, 3, P. & W.
Dynamo for Electro-plating, etc.

SEND FOR OUR LATEST LIST.

GEO. PLACE MACHINE CO.,

Warehouse: 511 and 513 WEST 13th STREET.
Office: 120 BROADWAY, NEW YORK.

SECOND-HAND MACHINE TOOLS.

ENGINE LATHES.

1 14 in. x 6 ft. Bogert.
1 15 " x 6 " Blaisdell.
1 15 " x 8 " Fitchburg.
1 16 " x 8 " Bement.
1 16 " x 6 " F. E. Reed
1 16 " x 6 " Perkins.
1 18 " x 8 " Munzer.
1 18 " x 6 " Pease.
1 20 " x 6 " Bullard.
1 20 " x 8 " Pease.
1 24 " x 14 " Dexter.
1 26 " x 10 " New Haven.
1 26 " x 25 " L. W. Pond.
1 29 " x 12 " Fifield.
1 30 " x 12 " Pease.
1 34 " x 20 " Perkins.

PLANERS.

1 16 in. Lathe and Morse Crank.
1 16 " x 16 in. x 3 ft. Walter Bros.
1 22 in. x 22 in. x 4 ft. Pond.
1 28 " x 28 " x 7 " New Haven.

DRILL PRESSES.

3 Milliken Light Bench.
1 10 in. 3 Spindle Slate.
2 No. 3 4 Spindle Garvin.
2 13 " Burnham Sensitive.
2 No. 2 4 Spindle Garvin.
1 " 4 6 " "
1 3 Spindle Pratt & W.
1 24 in. Cincinnati.
1 5 ft. Niles Univ. Radial.

SHAPERS.

1 10 in. Boynton & Plummer.
3 15 " Juengst Friction.
2 15 in. Wood and Light Traverse head.
1 18 in. Putnam Traverse head.

SCREW MACHINES.

1 No. 00 Garvin, wire feed.
1 " 2 Brown & Sharpe.
1 " 5 " "

MISCELLANEOUS.

2 16 in. x 5 ft. Gage Fox Lathe, square arbor and chasing bar.
1 Gage Valve Miller.
1 No. 1 Brown & S. Surface Grinder.
1 42 in. G. & E. Auto. Gear Cutter.
2 Garvin Auto. Gear Cutters
1 Slate Auto Gear Cutter.
1 6 in. Bement Slotter.
1 10 in. Newton Slotter.
1 No. 2 National Bolt Cutter.
1 Pratt & W. Die Sinker.
1 5 in. Cutting-Off Machine.
1 No. 2½ Pratt & W. Screw Machine.
1 No. 31 Cutting and Drawing Press.
1 3 in. Armstrong Power Pipe Machine.
2 Bicycle Rim Rollers.
1 No. 3 Toledo Power Press.
1 No. 0 Garvin Univ. Miller.

Also, large number of other machines. Write for a complete list and detailed description.

THE GARVIN MACHINE CO.,

LAIGHT & CANAL STS., NEW YORK.

FOR SALE OR RENT

On easy terms, or will rent for a term of years, A Brick Foundry and Machine Shop connected, located in Canton, Ohio and available to tracks of three railway systems. Main building 300x40 with power house attached, and detached office building. Shop fully equipped with power line shafting and cupola. Address,

NATIONAL HOT WATER HEATER CO.,
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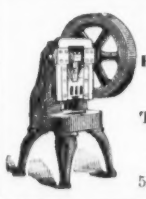

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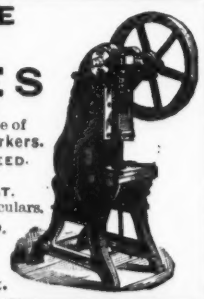

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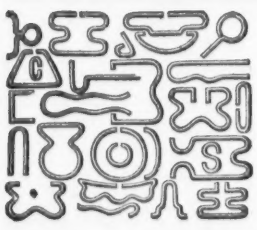

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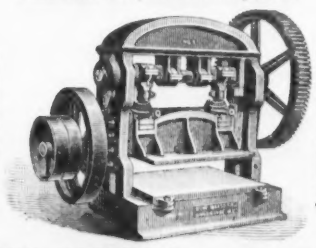

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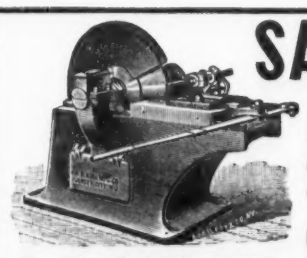

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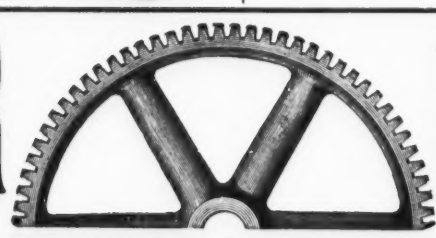

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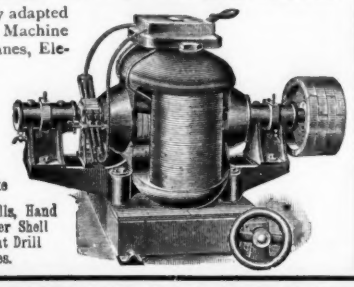

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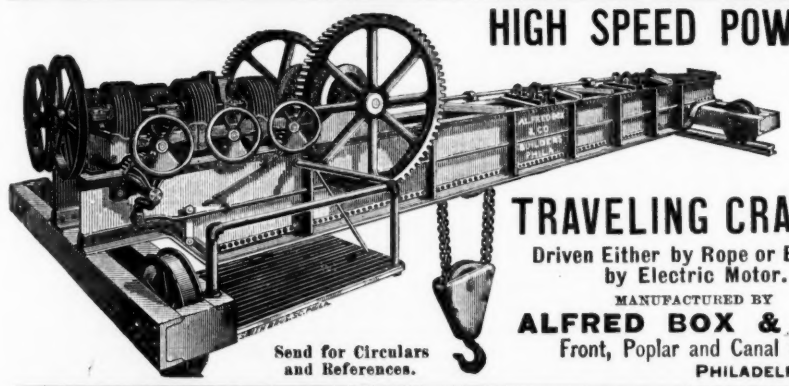

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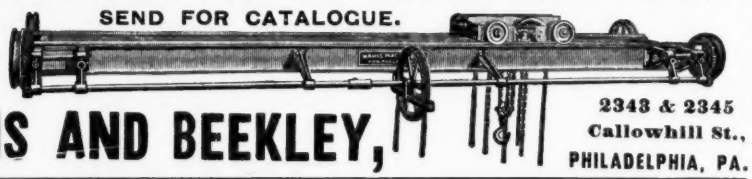

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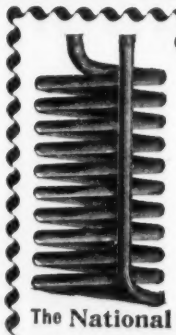

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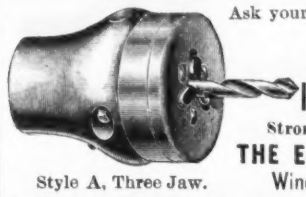

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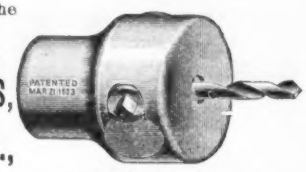

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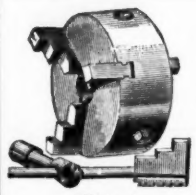

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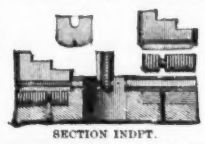

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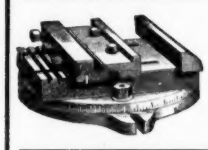

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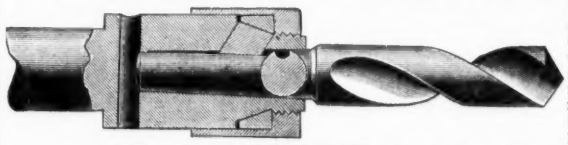

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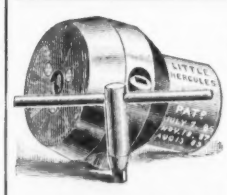

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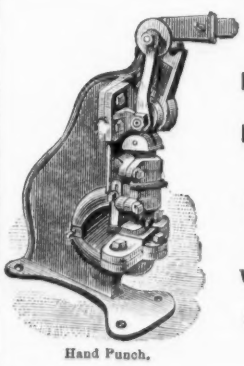

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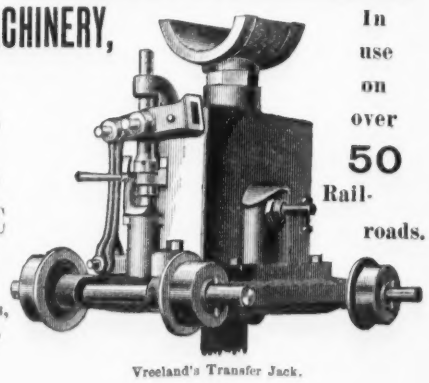

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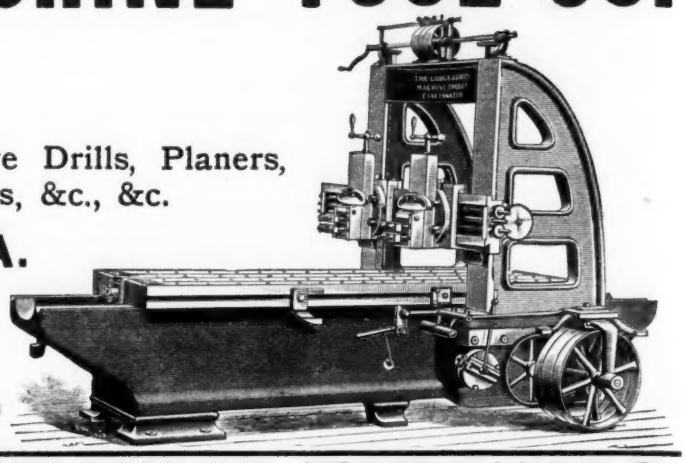

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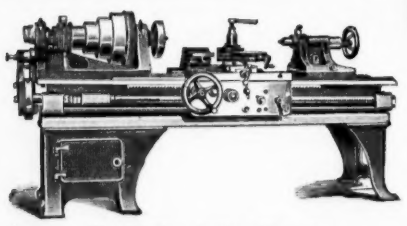

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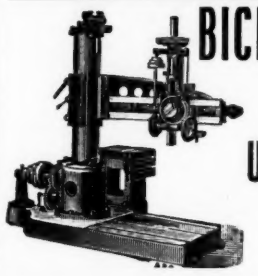

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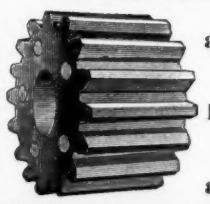

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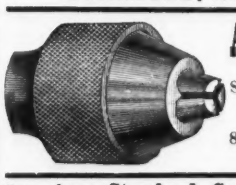

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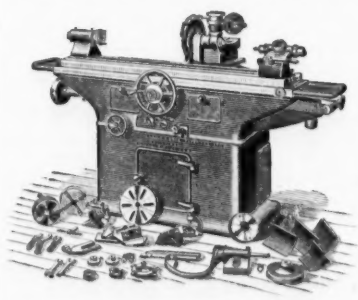

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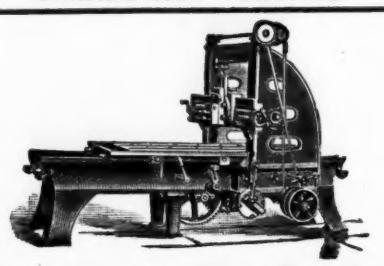

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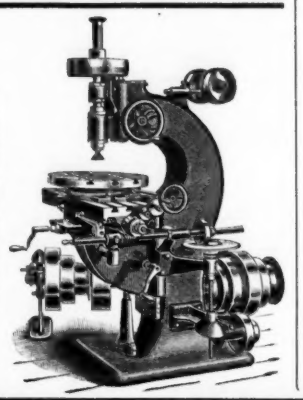

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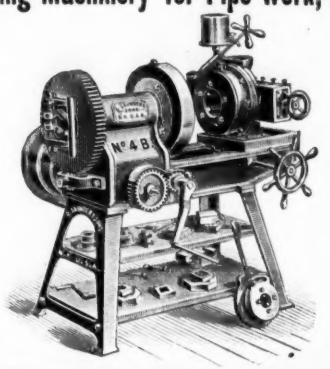

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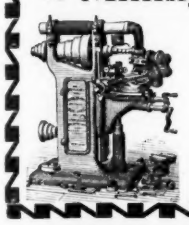

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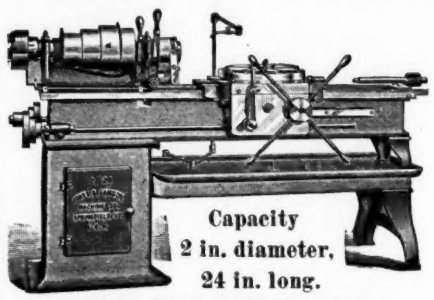

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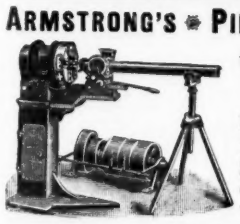

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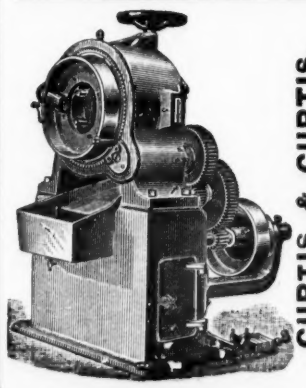

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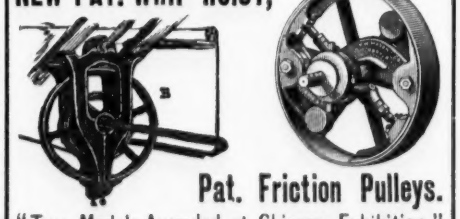

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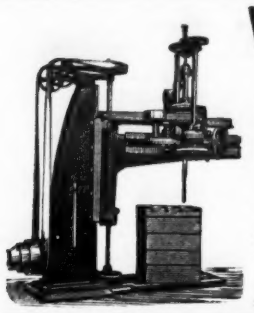

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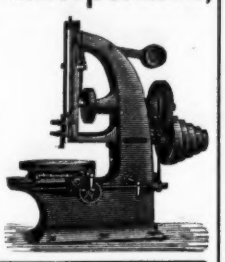

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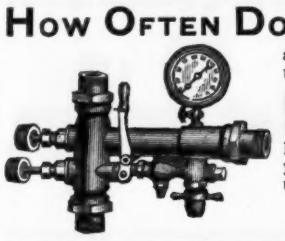

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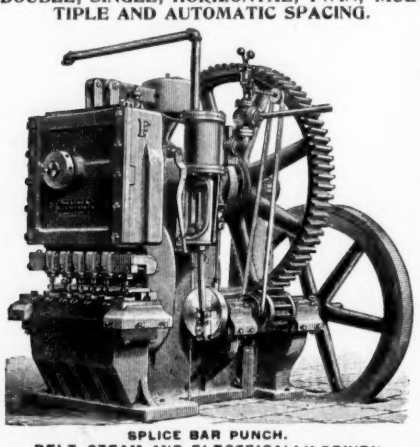

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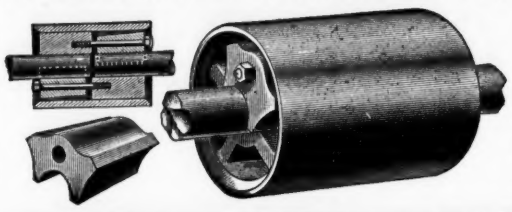

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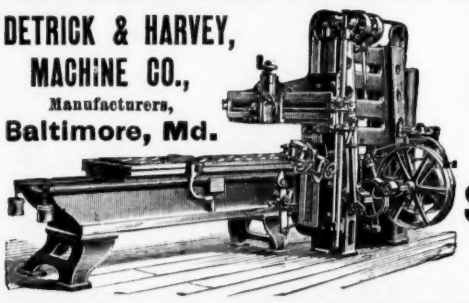

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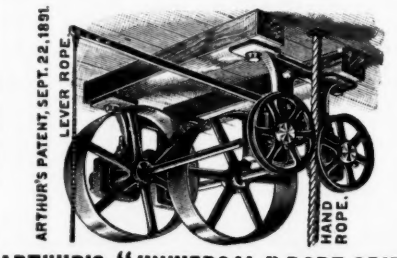

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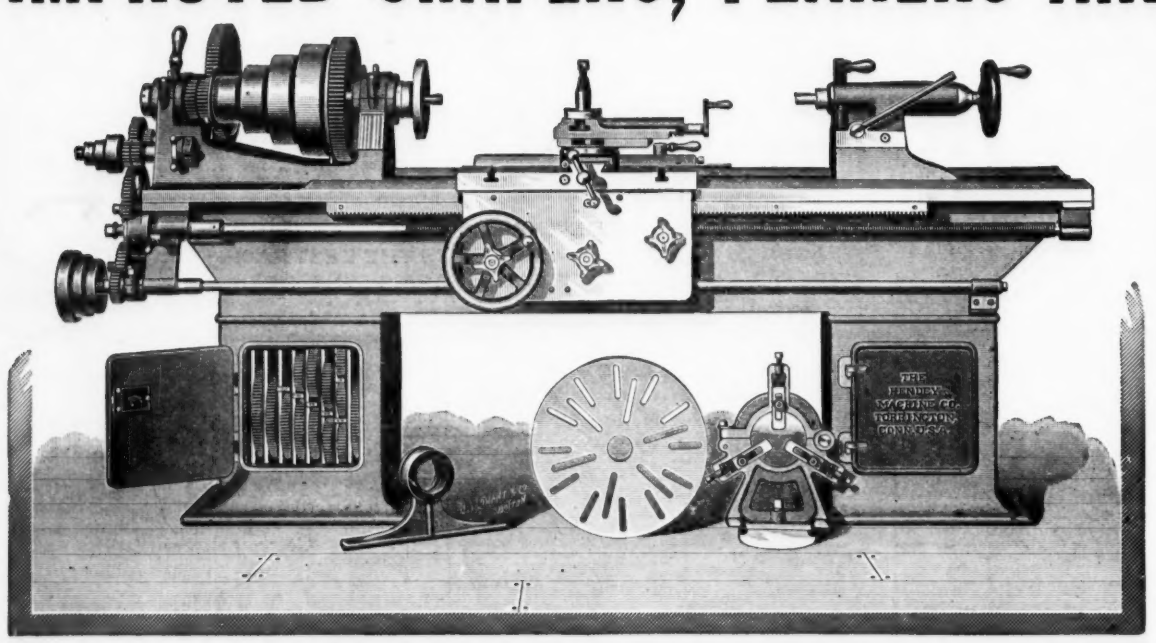

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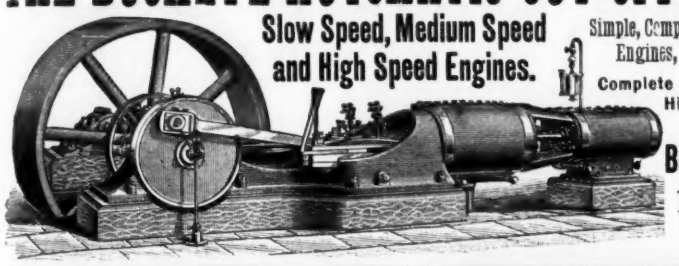

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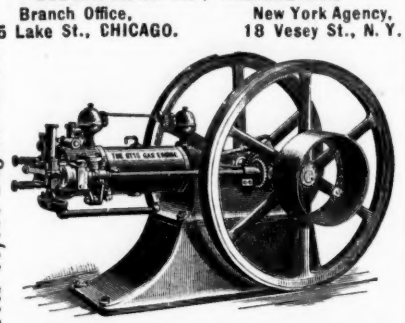

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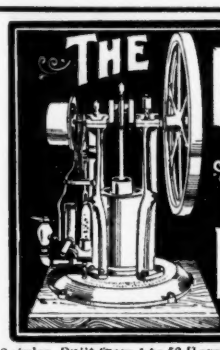

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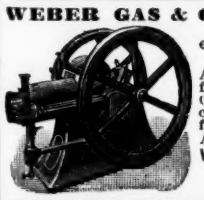

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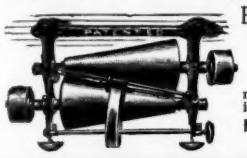

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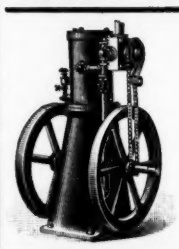

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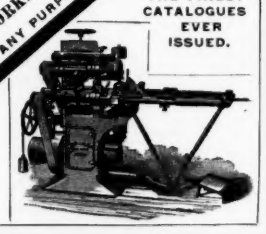

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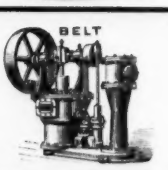

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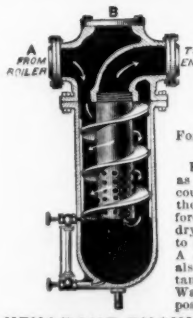

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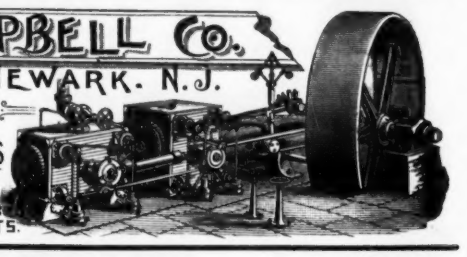

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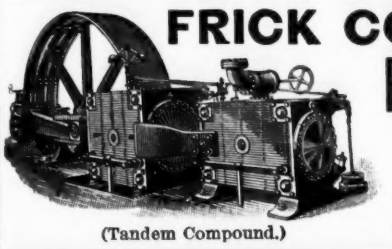

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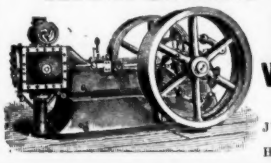

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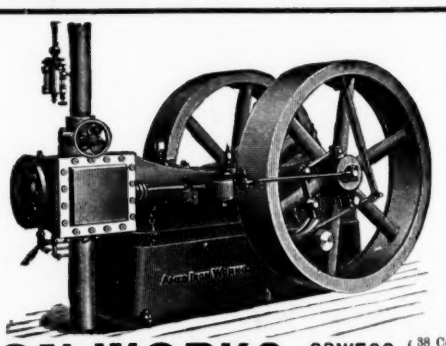

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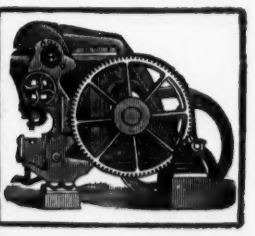

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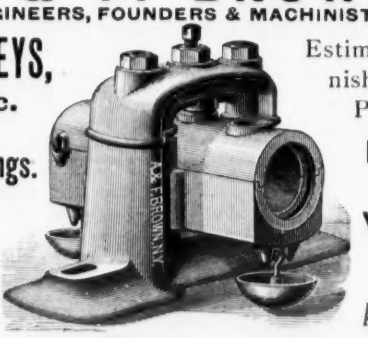

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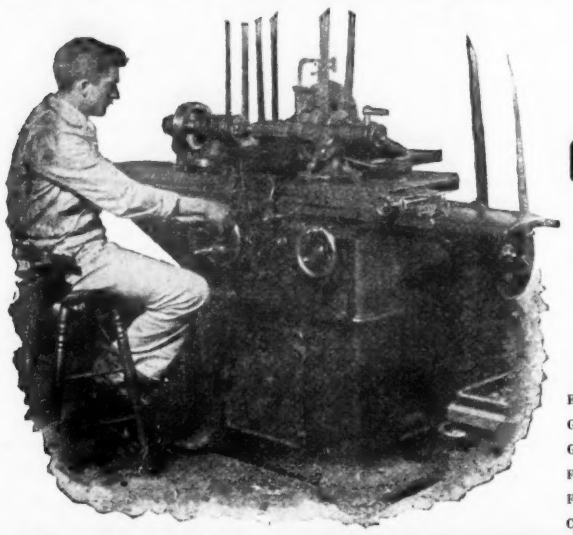

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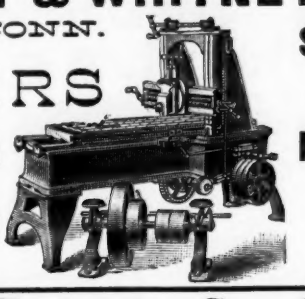

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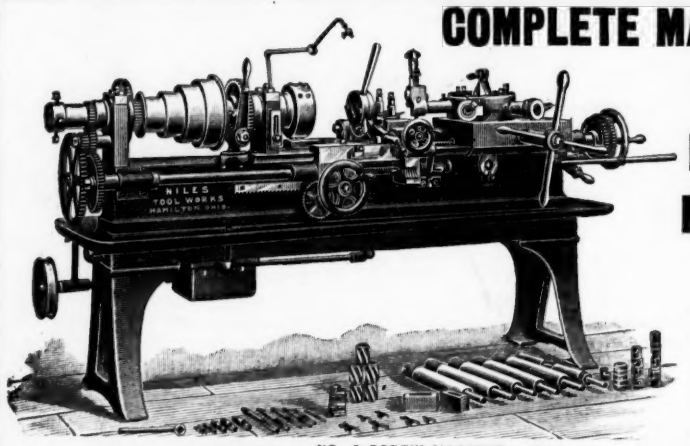

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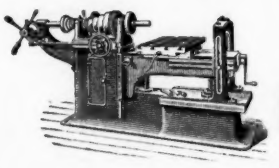

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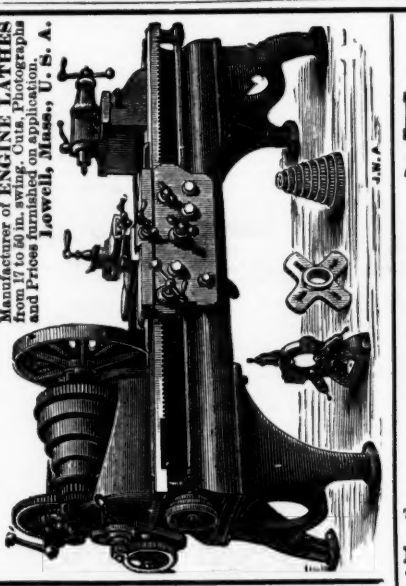

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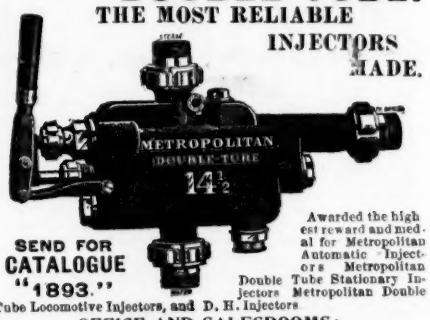

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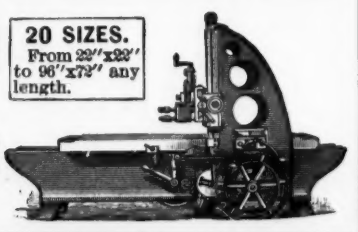

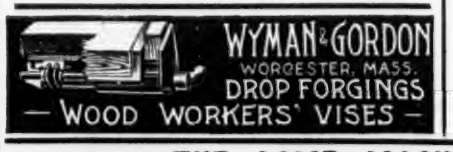

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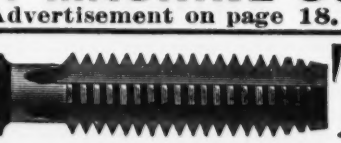

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